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TO THE

SECOND EDITION.

THE principal Parts of this Treatiſe were firſt diſpoſed into Order, to ſerve as Materials for a Courſe of Lectures and Experiments; which, in the Year 1737, were given at *Leyden*, to a Society of Gentlemen, moſt eminently diſtinguiſhed for their Skill, in all Branches of Natural knowledge. This will be readily allowed, when it is known, that *Van Swieten* and *Gronovius* were of the Number. *Cramer*, who had collected the Chief of theſe Materials, and made the Experiments, had been inſtructed in Mineralogy, and in the Practice of Metallurgy, by the greateſt Maſters in *Germany*; and at the time above-mentioned, and for ſome Years before, was employed by Doctor *Iſaac Lawſon*, as his Operator in Chemiſtry. This laſt named Gentleman, had reſided much longer at *Leyden*, than thoſe Foreigners uſually do, who go there to qualify themſelves for the Practice of Phyſick. He then employed himſelf in the Cultivation of thoſe Arts which he had there been taught; particularly, of Chemiſtry; and was highly eſteemed for his Skill therein; and lived in great Intimacy, with *Boerhave*, *Van Swieten*, *Gaubius*, *Gronovius*, *s'Graveſand*, *Albinus*, and with ſeveral other Men of great Learning, who reſided in that Univerſity, and which was then in its moſt flouriſhing State; as alſo with *Linnæus*, who was occaſionally there. Doctor *Lawſon* afterwards ſerved as Phyſician to the *Britiſh* Army in *Flanders*; where, by his Death, in the Year 1745, the World was deprived of the Advantage of many uſeful Diſcoveries. To him we owe ſeveral of the Obſervations contained in this Work, to which *Van Swieten*, *Gronovius*, and others of the learned Gentlemen before mentioned alſo contributed. But the Care and Trouble of reducing the Materials into Order, and writing them out fair for the Preſs, devolved entirely on Doctor *Lawſon*, as fully appears from his Letters to the † Gentleman who hath ſupplied us with theſe anecdotes, and who, in Juſtice to the Memory of ſo worthy a Man, thought proper to make known how much he had contributed, to this Performance. If any Thing can add to the high Reputation of this Work, it muſt be the Knowledge of its having been compoſed under the Direction and Patronage of Men ſo diſtinguiſhed for their Knowledge in Natural Hiſtory, and in every Branch of the Chemical Art.

In this SECOND Edition, the *Liſt of* Engliſh *Authors* has been enlarged; and the References to the Philoſophical Tranſactions of the Royal Society, brought down to the Year 1764.

† Doctor Brownrigg.

PREFACE
TO THE
FIRST EDITION
In 1741.

I SHALL, in this compendious Work, give the Reader the Elements of the Art of Aſſaying, that is, that Part of Chemiſtry, which conſiſts in a ſtrict Examination of Minerals, by Means of a proper Apparatus. I have written this chiefly, that it may be of uſe to ſuch Lovers of Chemiſtry as apply themſelves to the Study of mineral Matters. For this Reaſon, ſuppoſing that ſome of the ſlighteſt and moſt common Chemical Preparations were in ſome meaſure known to the Reader, I have been very ſhort about them, when I have had Recourſe to them in the Practical Part of the docimaſtical Art, except perhaps in ſome Places, that required a more particular Deſcription, as being little taken Notice of in the common Chemical Proceſſes. Therefore I thought it proper, previouſly to give a ſhort and ſpecial Theory of this Art, that thoſe who ſhould come to the Proceſſes, might already be acquainted with certain Things neceſſary to be known; that by this Means the Mind might be more compleatly Inſtructed in the making of the Apparatus, and the different Manners of proceeding be more eaſily underſtood. I have begun this Theory by an Explication of the leſs compound Objects of the Art, that theſe being found pure, might be diſtinguiſhed by their outward Form, or by the ſlighteſt Trial, eſpecially in the Fire. The ſimple Stones have rendered this Matter the moſt difficult: For almoſt all Authors have ſettled the different Claſſes of them only from their Figure, Tranſparency, Colour, &c. which Method, however, can be of little ſervice for our Purpoſe, and even in general. Thence it is, that there are Exceptions in every one of theſe Claſſes, on Account of ſome Reſemblance with regard to the Particulars juſt mentioned: So that Stones, which are called by ſome general Name, do not always reſemble each other as to the other Characteriſtics, even the more eſſential, which for this Reaſon ought not to be neglected upon any Account. And as it is no ſmall Help towards a ſolid Knowledge of Compound Minerals, to know the Action of the ſimple Ones upon each other, provided one has a Regard to the Conditions requiſite in every Caſe, and no unſeaſonable Fictions are admitted; I have for this Reaſon explained the Virtues of the Menſtrua in the ſecond Chapter. In the mean time, let none expect to have this Matter completely treated here; I mean as far as it is known from the Experiments hitherto made; becauſe it cannot be exactly known otherwiſe than from the Proceſſes themſelves. Therefore, I have inſerted very few of theſe, and even none but ſuch as might be confirmed by the eaſieſt Trial. Had I done otherwiſe, I muſt have ſuppoſed that many Things were already known to the Reader, which are familiar only to experienced Artificers, to whom it would have been an uſeleſs Trouble to propoſe them. I have, for the ſame Purpoſe, given a Deſcription of the Inſtruments.

It is eaſy to conceive, that it has not been in my Power to mention all compound Minerals, on Account of the numberleſs Differences proceeding from their various Qualities, Proportions, and Compoſitions. Wherefore, I would have what I have ſaid on theſe Matters, conſidered only as a Specimen, which, however may be very uſeful, and even ceſſary to young Beginners.

I have added a ſhort Deſcription of the Works which are chiefly and ſtrictly Docimaſtical, to which I have annexed Explanations of the Terms. Then follows a ſhort Account of the Effects, and of the Utilities reſulting from them in ſeveral Arts and Sciences, as far as theſe Things can be underſtood here. This is what I had to ſay concerning the Order I have propoſed to myſelf in treating this Theoretical Part.

But, as I have, for ſhortneſs Sake, ſeldom quoted any Authors in this Work, I ſhall here mention in general thoſe from whom I have borrowed; though an indefatigable Labour, the cloſeſt Inſpection, and Hands that were not afraid of the Blackneſs of Charcoal, have indeed been my chief Maſters in this Art. As to the Theory of it, Dr. *Stahl* has, in a clear Manner, given us the Principles thereof in many of his Writings. Dr. *Henckel* has given us Inſtructions about compound Minerals, and chiefly about metallick Ores, eſpecially in his Pyritology. Mr. *Ercker*, in his Treatiſe written in *Germany*, called *Probier-Buch*, and *Agricola*, in his Treatiſe *De Re Metallica*, Lib. VII. have given us the Proceſſes themſelves, to which *Modeſt. Fachſens* has added ſome few Things of his own. As to the other Authors, they have borrowed all the Materials from thoſe above-mentioned, or have not been made uſe of by me, becauſe I knew them not.

If the Reader approves of this Work, he may expect ſome others, that will perhaps be more elaborate.

A
LIST
OF THE
Chief *ENGLISH* AUTHORS,
WHO
Have treated of MINERALS and METALS.

W. LEWIS, M. B. F. R. S. *Commercium Philoſopho-Technicum*, Lond. 1763, 4to.

I. F. Henckel: *Pyritologia*, or, *a Hiſtory of the Pyrites*, Lond. 1757, 8vo.

M. da Coſta: *A Hiſtory of Foſſils*, Lond. 1757. 4to.

Llhwyd: *Lithophylaceum Britanicum*, Lond. 1699 and Oxf. 1763, 8vo.

William Borlace: *The Natural Hiſtory of Cornwall*, Lond. 1758, Folio.

Gabriel Plattes: *A* Diſcovery of ſubterranean Treaſure, *viz.* Of all Manner of Mines and Minerals from Gold to the Coal, with plain Directions and Rules for the finding of them, in all Kingdoms and Countries, &c. *This ſmall, but curious Tract hath often been printed at* London *in* 4to; *and lately in* 8vo. *at the End of a Tranſlation of* Alonſo Barba.

Albaro Alonſo Barba: Art of Metals, the 1ſt and 2d Book, tranſlated from the *Spaniſh* by *Edward* Earl of *Sandwich*, *Lond.* 1674, in Two Parts, 8vo, and lately reprinted. N. B. The Original is in five Books.

John Webſter: Metallographia, Or an Hiſtory of Metals, &c. *Lond.* 1671. 4to.

Robert Boyle, Eſq. General Heads for the natural Hiſtory of a Country, *Lond.* 1692, 12mo. *In this Book the Author lays down various judicious Rules for the Diſcovery of Ores and Minerals. Many curious Things relating to Metals and Minerals, are to be found diſperſed in his philoſophical Works.*

Sir *John Pettus:* Fleta Minor; the Laws of Art and Nature in knowing, judging, aſſaying, fining, refining, and inlarging the Bodies of confined *Metals*, in Two Parts. The firſt contains Aſſays of *Lazarus Ercker*, Eſſay-maſter General of the Empire of *Germany*; in Five Books, originally written by him in the *German* Language, and intituled Aula Subterranea. The Second contains Eſſays on metallick Words, as a Dictionary to many pleaſing Diſcourſes, *Lond.* 1686, Folio.

John Houghton: A Collection for the Improvement of Huſbandry and Trade, 4 Vols. *Lond.* 1727. 8vo.

In Vol. I. You have ſome Obſervations

On Nitre, No 11, 12.
Of Sulphur, No 19, 50. Vol. 2. No. 222, 237.

In Vol. II.

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Of Allom, No 238.

In Vol. III.

Of Soap, No 405.

In Vol. IV.

Of Minerals, *&c.* p. 290—1—2.

Of Salt *Spaniſh*, *French*, *Portugal*, *Scotch*, and *Newcaſtle*, p. 454, *&c.*

John Ray: A Collection of *Engliſh* Words not generally in uſe. *To this Book is ſubjoined* an Account of the preparing and refining ſuch Metals and Minerals as are gotten in *England*, *Lond.* 1737, 8vo. *viz.* the fining Silver in *Cardiganſhire.* The Preparing and Smelting Tin in *Cornwall.* The Manner of the Iron-work at the Furnace and at the Forge. The Wire-work at *Tintern* in *Monmouthſhire.* *Modus faciendi Vitriolum coctile* in *Anglia:* From *Wormius* in his *Muſeum.* The making of *Minium* or Red-lead. The Allum-work at *Whitby* in *Yorkſhire.* The making Salt at *Namptwych* in *Cheſhire.* The Manner of making Salt of Sea-ſand in *Lancaſhire.*

John Lawrence: A new Syſtem of Agriculture, *Lond.* 1726. Folio. In this Work is inſerted what he hath collected

Of Mines, Minerals, and Quarries	p. 172
Of Copper	175
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Of Salt, Sulphur, *&c.* in the Earth	183
Of Salt made and Salt-works	186
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Ant. Neri: Art of making Glaſs, with Notes by *Kunkel* and *Merret*, Lond. 8vo.

H. Blancourt : The Art of Glaſs, Lond. 1699 8vo.

Pyrotechnical Diſcourſes, containing

John Kunkel: An Experimental Confirmation of Chemical Philoſophy, &c. *George Ern. Stahl:* A ſhort Diſcourſe on the Original of Metallick Veins. *John Chriſt. Fritſchius:* The Grounds of Pyrotechnical Metallurgy, and Metallick Eſſaying.

Theſe Treatiſes were tranſlated from the Latin by Mr. *John Moult*, Chemiſt; but there being in the Original many Sentences of *German* interſperſed,

ſperſed, he hath left them untranſlated, probably not underſtanding that Language, Lond. 1705 8vo.

Robert Plot L L. D. Natural Hiſtory of *Stafford-ſhire. Oxford* 1686. in Folio. of Coal-pits, Chap. III. § 31, 32, 34, 36, 37, 60, 61, 62.

Charles Leigh, M.D. *Natural Hiſtory of Lancaſhire, Cheſhire, and the Peak in Derbyſhire*, Oxf. 1700 Folio.

Edward Brown, M. D. A brief Account of ſome *Travels* in divers Parts of *Europe*, &c. with ſome Obſervations on the *Gold, Silver, Copper, Quickſilver Mines*, &c. of *Hungaria*, &c. *Lond.* 1685, Folio. and 4to.

William Waller: An Eſſay on the Value of the Mines late of Sir *Carbery Price*, *Lond.* 1698, 8vo.

The *Philoſophical Tranſactions* of the Royal Society

Tripoly, Vol. li. part 1.
Marble, Vol. li. part 1.
Giants Cauſeway, No 485. Vol. xlviii. part 1. Vol. xlix. part 2. Vol. lii. part 1.
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Aſbeſtos, Vol. li. part . 2.
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Diamonds and Gems, No 476, 483. Vol. lii. part. 2.
Tourmalin, Vol. li. part 1. and Lyncurius Antiquorum *ibid.*
Coal, No 250, 336. Vol. li. part 2.
Coal Balls, No 460.
Peat, Vol. l. part 1.
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Sulphur, Vol. xlix. part 2.
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Figured-Foſſils, No 482, 490, 496. Vol. xlviii. part 2. Vol. xlix. part 1. Vol. xlix. part 2. Vol. l. part 1. Vol. l. part 2. Vol. li. part 2.

William Brownrigg, M. D. F. R. S. The Art of making Common Salt, as now practiſed in moſt parts of the World; with ſeveral Improvements propoſed in that Art, for the uſe of the *Britiſh* Dominions. *N. B.* In this work is included the Art of preparing Bay-Salt, 8vo. 1748.

For the Sake of ſuch as underſtand *Latin*, we muſt not paſs by that magnificent and laborious Work of *Emanuel Swedenborgius*, intituled, *Principia Rerum Naturalium, ſive novorum Tentaminum Phænomena Mundi Elementarii Philoſophice explicandi. Dreſdæ & Lipſiæ* 1734, in 3 *tom.* in Folio; in the 2d and 3d *tomes* of which he hath given the beſt Accounts, not only of the Methods and neweſt Improvements in metallick Works in all Places beyond the Seas, but alſo of thoſe in *England*, and our Colonies in *America*; with Draughts of the Furnaces and Inſtruments employed. It is to be wiſhed we had Extracts of this Work in *Engliſh*. So induſtrious are the *Swedes* in improving themſelves in the Art of Metallurgy, that they ſend young Gentlemen yearly to travel, not only all over *England*, but all over *Europe*, to learn every Thing new in regard of Mines; while we in *England* ſit ſtill at Home, and ſeldom go beyond a County or two; though, if more diligent Search was to be made by Perſons of Skill, there is great Reaſon to believe that Nature hath enriched theſe our Iſles with as great ſubterranean Treaſures, even the Virgin Silver of *Potoſi* not excepted, as any other Spot of the ſame Extent.

Some brief Directions for making Obſervations and Collections, and for compoſing a travelling Regiſter of all Sorts of Foſſils, wherein are many good Rules for diſcovering Minerals and Ores, are printed at p. 99, *&c.* of the Appendix to

Dr. Woodward's *Foſſils of all Kinds digeſted into a Method*, 8vo. 1728.

As for Catalogues of Minerals and Ores already known in *England*, ſee

Chriſtopher Merret: Pinax Rerum Naturalium Britannicarum, continens Vegetabilia, Animalia & Foſſilia, Lond. 1667. 8vo.

Nehemiah Grew, M. D. *Muſæum Regalis Societatis*, or a Catalogue and Deſcription of the natural and artificial Rarities belonging to the Royal Society, *Lond.* 1681, Folio. But the moſt compleat is that elaborate Work,

Dr. Woodward's *Attempt towards a natural Hiſtory of the Foſſils of* England, Lond. 1729, 2 vol. 8vo.

Concerning the *Engliſh Laws* relating to *Mines* and *Metals*, you have a Propoſal for Laws by *Tho' Houghton*, in his *Golden Treaſury*, or the *Compleat Miner*, being Royal Inſtitutions or Propoſals for *Articles* to eſtabliſh and confirm *Laws, Liberties, and*

Cuſtoms of Silver and Gold Mines, to all the King's Subjects, in ſuch Parts of *Africa* and *America*, which are now or ſhall be annexed to, and dependent on the Crown of *England*, *&c. Lond.* 1693, 12mo.

The ſame Author hath given us another ſmall Treatiſe, entituled,

Rara Avis in Terris, or the compleat Miner, in two Books: The firſt containing the Liberties, Laws, and Cuſtoms of the *Lead Mines* within the Wapentake of *Wirkſworth* in *Derbyſhire*. The ſecond teacheth, the Art of dialling and levelling Grooves, a Thing greatly deſired by all Miners; being a Subject never written on before by any, with an Explanation of the *Miners Terms* of Art uſed in this Book, 1681, in 12mo.

Sir *John Pettus*: *Fodinæ Regales*, or the Hiſtory, Laws, and Places of the Chief Mines and Mineral Works in *England*, *Wales*, and the *Engliſh* Pale in *Ireland*. As alſo of the Mint and Money. With a Clavis explaining ſome difficult Words relating to Mines, *&c.* Folio. 1670.

The ſeveral other *Laws* now in force are ſcattered up and down in the *Statutes* at large: But that which gives the moſt Encouragement to Miners and Metallurgiſts, is the famous *Statute* procured by the Intereſt of the great Mr. *Boyle*, Anno 1 *Gul.* and *Mar.* Chap. 30. intituled, An Act to repeal the Statute made in the fifth Year of King *Henry* IV. againſt multiplying Gold and Silver:

Wherein it is enacted, that all Gold and Silver that ſhall be extracted by the Art of Melting and Refining of Metals, and otherwiſe improving of them and their Ores, be from henceforth imployed for no other Uſe but the Increaſe of Monies; that it be carried to the Tower of *London*, where the owner ſhall receive the full Value. And that for the future no Mine of Copper, Tin, Iron, or Lead, ſhall be hereafter adjudged a Royal Mine, though Gold or Silver may be extracted out of the ſame.

Anno 5 *Gul.* and *Mar.* Chap. 6.

An Act to prevent *Diſputes* and *Controverſies* concerning *Royal Mines*.

[illegible]

[illegible]

[illegible] Encouragement [illegible] great Quantities of [illegible] made of Silver extracted out of Lead [illegible] *Wales*. These Coins have on the [illegible] the King's Arms upon their Reverse, [illegible] *Feathers*, or both alternately. In the Cabinets of the Curious are also found Shillings of Queen *Elizabeth*, with an Eſcallop Shell inſtead of the Queen's Head; they were coined without Royal Licence, by one [illegible], of *Knaresborough*, in the *West Riding* of *Yorkſhire*, who got good Store of Silver Ore from his Eſtate there.

The *Laws* relating to wrought *Plate* were formerly collected into a ſmall Volume, which it is pity we have not a new Edition of, with the Addition of all the new Statutes; the Title was,

A Touchſtone for Gold and *Silver Wares*, or a Manual for Goldſmiths. By *W. B.* of *London*, Goldſmith. *Lond.* 1677, 8vo.

Mineral Laws of Derbyſhire, 1734, 8vo.

Laws and Cuſtoms of Miners in the Foreſt of Dean, in the County of Glouceſter, 1687, 12mo.

Pearce's *Laws and Cuſtoms of the Stannaries in* Cornwall, *and* Devon. *Lond.* 1725, Folio.

Opera Mineralia Explicata, &c. Lond. 1718, 8vo.

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THE

THE ART OF ASSAYING METALS.

PART the FIRST,

Being the THEORY of ASSAYING.

CHAP. I.

Of the Definition and Object of ASSAYING.

1. ASSAYING[*] is the Art of Separating *Metals*, *Semi-Metals*, *Sulphurs* and *Mineral Salts* from each other, and from other Bodies mix'd with them, ſo that it may appear, what Quantity there was originally of each in the Body under Tryal, or what Benefit may be reaped from the extracting of it.

2. All Minerals are the Objects of this Art: For the Bodies aforeſaid being ſeldom found naturally pure, and under their true Form, but moſt commonly mix'd and confounded with each other a thouſand different Ways, and with many kinds of Earths and Stones; it is proper that the Workman ſhould know

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[*] A Corruption, by the Workmen, of the Word *Eſſaying*, derived from the French *Eſſayer*, to try.

the Nature of all theſe Things, to be able to determine, what is requiſite for the Separation of them.

3. I ſhall, with the moſt renowned Dr. *Boerhaave**, call *Minerals* and *Foſſils* natural Bodies, formed in the Bowels of the Earth, or in its Surface, and whoſe Frame is ſo very ſimple, that no Eye, tho' ever ſo ſharp, has been able even with the beſt Microſcopes hitherto to diſcover in them any Variety, between the Parts containing, and the Things therein contained; but a perfect Likeneſs and Affinity of the Parts with the Whole: Though it is known that in moſt of theſe a Concurrence of fluid and ſolid particles hath been effected by certain Mixtures.

Corollary. He therefore that attempts to give a rational Account of the Art of Eſſaying, ought previouſly to give ſuch a Deſcription of the ſimpler Species of Minerals which enter into the Compoſition of the Concretes, as may be taken from their external Form, from their being ſimply put into the Fire, and from other ſlighter Experiments hereafter to be mentioned.

4. All Minerals hitherto known, may be referred to five Claſſes, *viz.* Metals, Semi-Metals, Salts, Sulphurs, Stones and Earths.

I. *Of* METALS.

5. *Metals*, when pure, are Bodies extremely ponderous, fuſible by ſeveral Degrees of Fire, ſolid in the natural Heat of the Atmoſphere, apt to be extended every way with the Hammer, and of the utmoſt Opacity. They are ſix in number, *viz.* Gold, Silver, Copper, Lead, Tin, and Iron.

6. Gold, *Sol*, whoſe Mark is (☉), has all the Characteriſticks (§ 5.) of Metals in their utmoſt Perfection. It loſes between $\frac{1}{19}$ and $\frac{1}{20}$ of its Weight, in pure diſtilled Water. Though ever ſo long kept in a State of Fuſion, and in the greateſt Fire, it loſes nothing of its Subſtance; as it is of a moſt fix'd Nature. It is infinitely malleable; it gives no Sound

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* Elem. Chem. Vol. I. p. 30.

when ſtruck; in the Fire it no ſooner whitens, but it melts; and then looks of a Sea-green at the Surface. *Aqua fortis* has no Power on it. Its diſtinguiſhing Colour is yellow.

Scholion. *The Operations hereafter to be made upon Gold, and which I ſuppoſe are as yet unknown to the Reader, will give him a more exact Idea of this Metal. I may ſay the ſame of the other Metals.*

7. Silver, *Luna* (☽) loſes $\frac{1}{11}$ or $\frac{3}{32}$ of its Weight in Water: In Fire it is as fix'd as Gold and melts in almoſt the ſame Heat. Next to Gold it is infinitely malleable, and eaſy to be bent. It reſiſts the beſt *Aqua Regis*, and is of the fineſt ſhining white.

8. Copper (♀) *Venus*, loſes between $\frac{1}{8}$ and $\frac{1}{9}$ of its Weight in the ſame Water. It is not very fix'd in Fire, but loſes a great Part of its Subſtance, in Exhalation and Droſs. It is likewiſe malleable, but much leſs than the foregoing. It gives a loud Sound, looks of a deep yellow, is not fuſible but by a great Heat, and no ſooner begins to whiten, but tinges the Fire with a moſt beautiful blueiſh green. All Salts, and Things containing Salts, corrode it, when applied to it, in which caſe it aſſumes a great Variety of Colours, eſpecially the fineſt green or blue.

Scholion. Foſſils *are here ſaid by me to be turned into* Scoriæ *or Droſs, if, when expoſed to the Fire, they aſſume the Form of Glaſs; a brittle Body, fuſible and fix'd in Fire, and indiſſoluble by Water.*

9. Lead (♄) *Saturnus*, loſes between $\frac{1}{11}$ and $\frac{2}{23}$ of its Weight in Water. It melts long before it reddens. It is not fix'd, but loſes much of its Subſtance by Evaporation in a great Fire, and, according to the Degree of Heat, turns entirely into a duſty or a vitreſcent Droſs, of a yellowiſh Colour, called Litharge (*Lithargyrium*.) It is very tenacious, and the ſofteſt of Metals. It gives hardly any Sound under the Hammer, and is of a bluiſh white Colour.

10. Tin, (♃), *Jupiter*, is the lighteſt of all Metals, It loſes $\frac{1}{7}$ of its Weight in Water. It is not of a fix'd Nature, but melts in a mild Fire, long before

it becomes red hot. It, in a ſhort Time, partly evaporates into Smoak, and partly becomes a *Calx*. It is leſs malleable than the foregoing, tho' not very hard: If bent, it makes a crackling Noiſe, its Colour is much like that of Silver.

11. Iron, (♂) *Mars*, loſes between $\frac{2}{15}$ and $\frac{1}{8}$ of its Weight in Water. It is extremely fix'd in Fire, which muſt be in its higheſt Degree to melt it: When in Fuſion, it loſes a conſiderable Part of its Subſtance; it ſparkles, it diſſolves into a Glaſs of a dark blue Colour, and into ſulphureous Vapours: It is the moſt rigid of Metals; however, if it is not immediately quenched upon being red hot, it is malleable enough, it is of a watery Colour, and is attracted by the Loadſtone.

12. Quick-Silver, (☿) *Mercurius*, though it has no other metallick Quality but its Ponderouſneſs, yet is almoſt univerſally reckoned a ſeventh Metal. It loſes $\frac{1}{14}$ Part of its Weight in Water. When pure, it is ever fluid, even in the coldeſt Weather, and of courſe not malleable. It has the brightneſs of Silver, and is of the utmoſt Opacity; being reſolved into Fumes by a middling Fire, it evaporates entirely, a very few reddiſh Grains like Sand excepted. Theſe Vapours, however, being collected, return into the ſame Mercury as before.

Scholion I. *Theſe are the Characteriſticks of the pureſt Metals, when ſeparate from each other. They therefore are not good, when two or more of them are mix'd together. For Inſtance, Copper, Silver, and Gold, when melted together with Tin, loſe their Malleability, change their Colour*, &c.

Scholion II. *The ſpecifick Gravities of Metals cannot be very exactly determined; for they vary a ſmall Matter; firſt, according to the different Heat of the Atmoſphere, which expands Water and other Fluids infinitely more than it does ſolid Bodies; and, by that unequal Diminution of the Weight, makes it impoſſible to aſſign them a conſtant Proportion, unleſs the Heat be determined with the greateſt Exactneſs.* Secondly, *according to the ſeveral*

ral Degrees of Pureneſs in the Water; which Difference is ſometimes found not inconſiderable. Thirdly, *According to the different Pureneſs of the Metals: For there is hardly any Metal found ſo very pure, but what may eaſily be demonſtrated to be mix'd with ſome others.* Fourthly, *According to the ſeveral Weight of the Atmoſphere itſelf: Though the Effect of its Variations be not very conſiderable. This accounts why there are as many different ſpecifick Gravities aſſigned to Metals, as there are Authors that have ſearched this Matter by Experiments. However, unleſs the Metals be of a very great Impurity, the Sum of all the Differences reſulting from the ſaid Cauſes is not ſufficient to hinder any particular Metal to be diſtinguiſhed from any other by its ſpecifick Weight.*

II. *Of* SEMI-METALS.

13. Theſe agree with the foregoing, except that they have not near the ſame Malleability, if even they have any. They are as follow.

14. *Zink*, is a Body of a blueiſh white Colour; brittle and ſomewhat tenacious; of conſequence ſomewhat malleable, though much leſs than Metals. It melts in a gentle Fire, ſoon after it ſmoaks, and then ſticks to the Furnace in the Form of exceeding light white Flowers. In a greater Fire it burns with a Flame of the moſt beautiful green Colour, which evidently betrays an Abundance of Sulphur.

15. *Biſmuth*, *Tin-Glaſs*, when broken, appears to conſiſt of ſmall cubic Particles, and theſe again conſiſt of minute *Laminas* applied to each other. It is more brittle than the foregoing, but differs little externally, except that it does not aſſume the blue Colour, but looks rather of a ſhining and very light yellow.

16. *Regulus of Antimony*, is extremely brittle. When perfectly cleanſed from Sulphur, it ſurpaſſes the foregoing in whiteneſs: It requires a greater Fire to be melted; which renders it eaſy to be diſtinguiſhed from the two former.

17. There is among the Minerals another Body, which deſerves to be claſſed among the Semi-Metals,

on account of its vaſt Affinity to them, *viz. Arſenick* (⚯). This, if perfectly pure, muſt be white; it grows ſoft in the Fire, and then evaporates entirely into a thick white Smoke, that has the unpleaſant ſmell of Garlick; but when grown cold, it gathers into a ſolid, half tranſparent, ponderous, white body. It is not inflammable. When expoſed to the Air, it aſſumes a ſmall milk white-Skin; it may be reduced into a *Regulus*, very much like Antimony, and inflammable.

Corollar. Some refer Arſenick to the Claſs of Sulphurs; but very improperly, as it plainly appears from the Compariſon of its Characteriſticks juſt mentioned, with thoſe of Sulphurs.

III. *Of* SALTS.

18. Salts are Bodies diſſoluble in Water, melting or volatile in the Fire, but not inflammable.

19. Firſt of all, there are two kinds of pure and natural Salts among Minerals; one neutral, the other acid.

20. The neutral is of two Sorts; the firſt is common Salt (⊖), *Muria*, which, if pure, is always of the whiteſt Colour. It is ſemipellucid; diſſolves in pure Water, thickens in a gentle Fire, appears to conſiſt of ſeveral teſſellated, cubical and hexaëdral Cryſtals, joined together in truncated Pyramids; it crackles very loud, when thrown into the Fire.

21. The other is called Nitre (⦶), which, when diſſolved in pure Water, and cryſtallized, according to Art, aſſumes a priſmatical hexaëdral Figure, terminated by ſmall pyramidical Columns of the ſame Number of Angles. It is white, and nearly tranſparent. In a pure Fire, ſuch as the Rays of the Sun collected, or in Veſſels defended from any Fuel falling into them, it grows liquid by a gentle Heat: In a great Fire, it partly perſpires through the Veſſels, and partly reſolves into a Smoke, which is the Nitre itſelf; but, any inflammable Body being added to it, it burns with a very

ry great Noiſe, and, with the Matter added, changes in part into an *Alkali*.

22. There is alſo an acid Salt, called *Vagum Foſſile*, found in Vitriol, Sulphur, Allom, nay, almoſt every where: It is ſeldom pure, if ever; but adheres either to Metals (and chiefly to Copper and Iron) or to calcareous Earths, more commonly to thoſe that turn into Glaſs, nay to the very Flints; or is mix'd with inflammable Foſſils. But what diſtinguiſhes it from all others is, its being more ponderous and more fix'd than all the other Acids that are known, which it drives out of its *Matrices*; mix'd with pure Water, it grows very warm; it mixes with common *Sulphur*, accompanied with fat Matters of any kind. What its Power upon Metals is, will be ſhewn hereafter, in our Chapter of *Menſtrua*.

23. To this Claſs might perhaps be referred the Acids of common Salt and Nitre. However, as they can be extracted by Chemiſts from theſe Salts, only, it is not very ſure that they are found naturally any where.

Corollar. It is a queſtion whether there may be found, naturally, any true and perfect Alkaline Salt, whether fix'd or volatile, in the mineral Kingdom? The former ſeems to be confirm'd by the Salt of the *Spa* Waters, and by the *Natrum* of the Ancients: Marble, and Stones either fetid or eaſy to be cleft, poſſibly contain the latter. But both Points require a more accurate Examination. See. *Fr. Hoffman* * and *Henckel* †.

IV. *Of* Sulphur.

24. Whatever is inflammable, is called among the Chemiſts by the general Name of *Sulphur*. You find it in the mineral Kingdom, always mix'd with Acid, (§ 22.) otherwiſe the pure inflammable Mineral ſeems not to differ from the vegetable and animal; nor does

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* Diſſertat. Phyſico-Chem. Lib. II. Obſ. I.

† Tractatu de Appropriatione, pag. 126. n. 4.

it ſeem that there are two kinds of it in Nature: In this Caſe the whole Difference between the ſeveral kinds of *Sulphur*, would conſiſt only in their various Mixture with heterogeneous Matters. As therefore Nature hardly affords any pure inflammable Matter, this is not the Place to treat of the ſeveral kinds of *Sulphurs*, which are never without Mixture: Our Deſign requires, that we ſhould mention thoſe only that are of the ſimpler kind.

V. *Of* STONES *and* EARTHS.

25. *Stones* are Bodies not diſſolvable by Water, not malleable, not inflammable, of the moſt fix'd Nature, and perfectly coherent.

26. When they conſiſt of minute impalpable Particles, little or not at all coherent, they are called *Earths*.

27. But when, being viſible, palpable, and extremely ſmall, they nevertheleſs appear ſtill minute Stones heaped together, they are called *Sand*, *Gravel*, and *Grit*.

28. Our Deſign chiefly requires, that we ſhould ſhew the Differences of Stones, reſulting from their different Changes in the Fire: Nor will it be needleſs to point out ſuch of their other Characteriſticks, as are eaſily apprehended by the Senſes.

29. Some of them will melt in the greateſt Heat of a Wind Furnace, and are ſaid to be of the vitrifying Kind: To which Claſs they are referred.

Nº 1. *Schiſtus*, or *cleaving Stone*, which is a Stone conſiſting of a heap of *Laminas* that cleave eaſily; it is opaque, very ſoft, moſt commonly black, in which Caſe it is harder, and goes by the Name of *Slate*, otherwiſe it looks of a dark blue, or aſh-colour. Theſe Stones, put in Veſſels cloſely ſhut, ſuſtain a moderate melting Fire, without any Alteration; when the Heat is increaſed, they are put in Fuſion; and then the firſt black kind of them turns into a clear black Glaſs. But ſome of the other Species are by the ſtrongeſt Fire raiſed up into a Scum, inſomuch that a ſmall Quantity of them will fill a large Veſſel, and then turn into a very ſpongy and light Maſs, that ſwims upon Water.

N° 2. Common *Potter's Clay* is heavy, and of a whitiſh blue Colour; in Water it ſoftens into a tenacious Paſte; a middling Fire hardens it firſt, and a ſtronger Fire at laſt runs it into a Glaſs of a dark green Colour.

N° 3. The *Boles* and *Terræ Sigillatæ*, or *ſealed Earths*, have an Affinity (N° 2.) with the foregoing, but are of a fatter Nature, and of different Colours. They harden to ſuch a Degree in a modern melting Fire, that they moſt commonly give Sparkles, when ſtruck with a Flint; in a ſtronger Fire, they turn into Glaſs, partly ſolid and green, and partly ſpungy and light, (as N°. 1.) To this Claſs belong a few Earths of the Nature of Marle, though not quite ſo fat.

N° 4. *Flint*, which is a vaſtly ponderous Stone, when ſtruck with a Steel, gives very bright Sparkles, which, being examined with the Microſcope, prove to be *Scoriæ* of melted Iron and Stone. It is infinitely hard, and of a great many Colours. It aſſumes a multitude of different Names, according to the Variety of its Colour, for the Beauty of which it is very much valued, though in conſideration of its Size it is ſometimes of no Price at all. If this Stone, either in its natural Surface, or when broken, is very cutting and full of Angles, it is called by the Miners *Quartz*: Some of them are eaſily put in Fuſion in a Wind Furnace; others reſiſt the greateſt Fire without hardly any Alteration, and might be thought not to belong to this Claſs; but, by means of a ſmall Quantity of Salt, or ſome other *Menſtruum*, nay by means of the *Alkali* in the Coals, they will melt in a naked Fire. When they are only minute Flints like Grains, heaped together, but not adhering to each other, they are called *Sand* or *Gravel*. But when they ſtick together, though diſtinctly collected, they are called a ſandy or gravelly Stone, which is of the ſame Nature as the Flint, and aſſumes in the Fire a Variety of Colours, Forms and Delicacy.

30. *Limeſtones* conſtitute another kind, which, when burnt in the greateſt Fire, are ſo changed as either to ſoften in the Fire immediately, or to cleave into Lime by adding Water to them. Of this Claſs are,

N°. 1. *Spatham*, or *Spaad*, which is a ſoft Stone, and will be render'd ſo very brittle by the mildeſt Fire, in which it makes a gentle Crackling, that you may reduce it into Duſt between your Fingers. It varies its Gravity, as it is more or leſs compact. It moſt commonly conſiſts of *rhomboidal*, often of priſmatical, parallel, and oblong Parts, variouſly tranſparent, and generally of a watery or milky Colour.

N° 2. *Marbles*, which are of a great many Colours, and often of various Colours at once. Marble is a hard Stone, moſt commonly opaque: If, after having been burnt in a great Fire, it is expoſed in the Air, or wet with Water, it generally cleaves with great Violence into a thin limy Powder: But this ſtill has an Exception; for there are Marbles extremely neat and fine, which, in a Fire not over-violent, turn into an opaque kind of Glaſs, but not at all into Lime.

N° 3. *Stalactites*, or *Dropt-Stones*, which is a light ſoft Stone commonly of a white or grey Colour, therefore always calcareous, and will always burn into Lime. It ſeldom proves of another Nature.

31. Finally, there are Stones which, in the greateſt common Fire, either do not change at all, or at leaſt are never melted, nor reduced into Lime by being wet: Whence they are very properly called *Apyri*, or ſuch whereon the Fire hath no Effect.

N° 1. *Chalk* deſerves the firſt Rank among theſe, as it ſuffers no Alteration, if pure, not even in the *Focus* of a Burning-glaſs. It is light, white, ſoft, and porous. It tranſmits Water through it, and ferments with all Acids, in which it alſo diſſolves. It is not fat, but rough to the Touch.

N° 2. The *chalky* and *impure Marles* come next: To their Claſs muſt be referred the *Terra Tripolitana*, or *Tripoly*, which is like Chalk, but lighter, and feels ſofter.

ter. It is found yellow, white, red, and grey; and hardens in the ſtrongeſt Fire to ſuch a Degree, as to give Sparkles with a Steel.

N° 3. *Aſbeſtus*, a Stone conſiſting of rigid and ſtringy Fibres wove together, and cutting each other acroſs. It varies very much as to its Weight. It ſcarce changes in the greateſt Fire, except that it commonly turns white, and becomes harder than before. There is a kind of very light *Aſbeſtus*, called *Suber Montanum*, which melts into a black kind of Glaſs [*].

N° 4. *Amianthus*, or *Earth-Flax*, which is little different from the foregoing, except that its Fibres are pliant and parallel; ſo that the *Virtuoſi* make Thread, Cloth, and Paper, with a certain kind of it. It ſuſtains a moderate Fire without being altered: But when it is expoſed to the greateſt Fire, it either partly or wholly loſes its Pliantneſs: This is chiefly true of that kind of *Amianthus*, which is friable between the Fingers, and is falſly called *Alumen plumoſum*: For it hardens in Fire to ſuch a Degree, as to ſtrike Light with a Steel [†].

N° 5. *Ollaris* [‡], *Lebetum Lapis*, *Pot-Stone* [a], which feels exactly like hard Soap: It is moſt commonly ſomewhat tranſparent; ſoft, ponderous enough, and very eaſily carved with a Knife. In the Fire, it turns white, and hardens to ſuch a Degree as not to be ſurpaſſed by Flints, and to ſtrike a Light immediately. But it cleaves in the greateſt Fire. A few kinds of Tobacco-pipe Clay belong to the ſame Claſs.

N° 6. *Talck*, it is a Stone conſiſting of ſmall Scales, lying one upon another: It has a ſoapy feel: It is ſometimes tenacious; reſiſts a great Fire, and ſuffers there no other Alteration, but its becoming more brittle.

N° 7. *Mica*, Glimmer or Gliſt, it is of the foregoing kind; ſhining, and brighter, black, gold or ſilver colour'd; nor can it be conquered by either Fire or Water.

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[*] A, Henckel. De Lapidum origine, p. 58.

[†] Idem, ibid. pag. 55.

[‡] Carol. Linnæi Syſtema Naturæ, Tab. I.

[a] *It may be ſo called, becauſe in* Switzerland *they turn Pots and Kettles out of it, that will bear the Fire to boil Meat in them.*

Many kinds of theſe Stones, which feel like Soap before they are burnt, become ſomewhat rough by the Force of Fire.

32. There are ſtill many other kinds of Stones, whoſe Differences are infinite as to their Figure, Colour, Hardneſs, Tranſparency, and Weight. I ſhall forbear to enumerate them; my chief Purpoſe requiring, that I ſhould only deſcribe here the moſt common of them, and thoſe in which the other Minerals moſt commonly lye hidden. Beſides, there are many Sorts of Stones that are Mixtures of ſeveral others, which it is not our Buſineſs here to mention, as we treat only of thoſe that are ſimple. As for the reſt, whatever other Stones are found, beſides theſe, may be referred to one of the hitherto mentioned Claſſes; though they poſſibly have other Characteriſticks belonging to them in a more ſpecifick Manner.

33. However, I by no means believe, that what I have hitherto ſaid, is ſufficient for a perfect Knowledge of all the Stones which Nature affords: For I have done only what I could, not what I would; and ſhould any one ſay ſomething better on the Subject, I would gladly lay hold of it. There is certainly ſuch an Infinite Combination of Forms and Proportions in the Mixture of Stones among themſelves, that no Eye is capable, even with the Help of Inſtruments, to diſtinguiſh them accurately. The Figures, Colours, and other the like outward Qualities, are ſeldom conſtant, as they depend upon a Multitude of Cauſes, not belonging to the Matter of the Stone itſelf: So that he may eaſily be deceived, whom forms any Judgment or Diſtinction from them. That Method is better grounded, which makes the Trials in ſeveral Degrees of Fire, firſt in cloſe Veſſels perfectly clean, and able to reſiſt Fire, and then in open Veſſels, and in a Wind Furnace, or a Smith's Forge.

4. Who can deny that there are many *Genus's* and *ies* of ſimple Minerals, beſides thoſe already tioned? It is not to be doubted, but that there , in the Nature of Things, Salts, and perhaps Metals,

tals, and Semi-Metals, different from thoſe above-mentioned, nay perhaps Minerals that could not be referred to any of theſe Claſſes: Nor can we deny it, when we conſider that Nitre, which, as far as we know, was a Secret to the Ancients, has been found out but a few Ages ago.

Coroll. As the Art of Aſſaying teaches the Nature and difference of ſimple Minerals, and the Mixture of thoſe componnded, its Uſefulneſs is evident for the compleating Natural Hiſtory. Nor is it leſs uſeful and neceſſary in Metallurgy. For as no Man can paſs any certain Judgment upon the Nature of Minerals, from the bare Inſpection of them, he muſt for that purpoſe have Recourſe to docimaſtical Experiments. Let us take, for an Example, ſome Lead Ore, of a yellowiſh green Colour, and mix'd with Cryſtals reſembling Spar, ſhooting like Nitre, which, as far as I know, is found in one Place only. Let us ſuppoſe a Man to have ſeen Lead Ore, of all ſorts, this very rare one excepted; the bare Inſpection, the Figure, Colour, and Weight of it, will never make him find out, that this Ore is very rich in Lead; which any Man ſkilled in theſe Things will confeſs to be true of many others. *Ercker* ſpeaks of Workers of Mines, who had, with no ſmall Detriment, miſtaken Ores of Tin for Ores of Iron *.

35. The Aim of docimaſtical Operation is twofold; *viz.* to know, *firſt*, what kind and what quantity of each Mineral is contained in the compounded Subject; *ſecondly*, what kind and how much may be extracted out of it, with ſome Benefit.

Scholion. *The Workers of Mines are often miſled by the Aſſayers, who make their Trials in ſuch a Method, and with ſuch Additions, as can never be uſed in greater Operations, on account of the vaſt Expence and Trouble wich attend them. For when the Operation is undertaken with that View, the Method of it ought to be ſuch as can be imitated and purſued in larger Works, or in the*

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* Vid. Laz. Ercker's *Probir. Buch.* pag. 120.

room thereof ſome other Method may be ſubſtituted equally beneficial.

CHAP. II.

Of Docimaſtical Menſtrua, *and the Preparation of them.*

36. BEFORE we treat of the Inſtruments and Veſſels, and come to the Operations themſelves, it is proper for us to ſhew the Nature of thoſe Bodies, which are to be contained in theſe Veſſels, directed and applied by theſe Inſtruments, and which ſhall act upon the Object of Aſſaying.

37. Thoſe Bodies, which, being applied to others according to certain Rules, diſſolve them ſo as to adhere themſelves in a State of Diviſion to the Particles of the Body diſſolved, and cannot ſeparate from them again of their own accord, are called *Menſtrua.* Theſe are chiefly divided into *dry*, and *moiſt*; which laſt are again ſubdivided many ways: But this being mentioned in all the Writings of the Chemiſts, we ſhall paſs it by in Silence, as we only treat of one Part of Chemiſtry: For we need only to explain in a ſpecial Manner, the Operations belonging to our preſent Purpoſe, and to acquaint the Reader with the Preparations of them.

Of METALS *and their Products conſidered as* Menſtrua.

Of LEAD.

38. See its Characteriſticks, *Chap.* I. § 9. When Lead is expoſed to a moderate Fire in an earthen Veſſel, the Surface of it is immediately covered with a thin tenacious Skin of *Scoriæ*, of different Colours: When the Fire is increaſed ſo as to render the Veſſels quite red hot, this Skin melts a little, and is thrown

to the Side of the Veſſel, where it turns into Droſs called *Litharge*. Then the Lead ſeems to boil and ſmoak, and ſmall Drops reſembling the firſt *Scoriæ* are inceſſantly produced, that ſwim upon the Lead like Oyl and are continually thrown towards the firſt. If the Fire is kept at the ſame Degree, the whole Maſs of Lead at laſt turns into *Litharge*.

39. If you put Copper into Lead thus ſmoaking, it cauſes a much briſker Ebullition, and the Copper as it were burſts, divides, and ſeems to become but one homogeneous Maſs with the Lead, which Maſs is brittle, and, when broken, its Surface, if there hath been added about half as much Copper, will have the Colour and Figure of a Piece of tempered Iron or Steel.

40. Gold and Silver likewiſe, melted with Lead, become brittle, and Gold eſpecially turns pale, by the leaſt Mixture of it.

41. Tin is melted with Lead, by a Fire not much greater than what would melt both ſeverally: But ſo ſoon as the Fire is increaſed ſo as to make the Veſſels turn red, the Tin immediately riſes above the Lead, like little whitiſh duſty Hillocks; ſo that one unſkilled in theſe Matters would be apt to think that Coals had fallen into the Metal: If they have been taken but a little while out of the Fire, they look like burning Coals. Tin thus calcined, when grown cold, has its Colour variegated with white, yellow and red.

42. Lead, ſo long as it keeps its metallick Form, can never join with Iron, though urged with ever ſo great a Fire.

43. Semi-Metals are eaſily melted with Lead by Fire, and a great Quantity of them deprives it of its Malleability.

44. This Metal muſt oftentimes be made into ſmall Grains, that it may be mix'd with the others, and its exact Weight be more eaſily determined.

But this Comminution is beſt made the dry way, in the following Manner, which is called Granulation. Put Lead in an iron Ladle, melt it on a gentle Fire;

ſo ſoon as it is perfectly liquid, pour it at once into a wooden Veſſel having a wooden Cover, or ſome other Veſſel in which a Fluid may be very ſtrongly ſhaken, without however any danger of its running out. But let the Sides of the Veſſel be well rubbed with Chalk or Wax; then let it be thoroughly ſhaken, ſo that the Lead, agitated within, may daſh ſtrongly againſt the Sides of the Veſſel; nor do you ceaſe this Motion, till it becomes ſolid: You will find the greater Part of the Lead, divided into very ſmall porous Grains. Let then the Chalk that ſticks to it be waſhed off; then ſift the Grains, to make them equal, dry them, and keep them from the Duſt in a clean Veſſel, for the Uſes hereafter to be explained.

Scholion I. *The Reaſon of doing thus is this. There are among Metals ſome, as Lead, Tin, and Braſs, which, when ready to melt, are extremely brittle, like wetted Gravel. The Chalk wherewith the Inſide is rubbed over, gives the Surface a vaſt reſiſting Force, and preſerves it from burning. Now, if the melted Lead be ſhaken and daſhed againſt the Sides of the Veſſel in the Manner aforeſaid, the Minute it begins to become ſolid, the Maſs, at that Moment being of the utmoſt Brittleneſs, is ſhivered into a minute Duſt, which can hardly be obtained any otherwiſe than by this manual Operation.*

Scholion II. *There are Cautions to be taken.* Firſt, *Let the Lead not be melted by too great a Fire; for this occaſions a thin Skin on the Surface, which though taken away is immediately ſucceeded by another, which, mixing with the Lead during the ſhaking, hinders very much the Succeſs of the Operation, it being too tenacious.* Secondly, *Let the Lead be ſufficiently fluid; leſt the Maſs, ſo ſoon as poured in, ſhould wax cold before it might be broken to pieces.*

Corollary. It is then plain, that this Granulation cannot be made with ſuch Metals, as are more tenacious in proportion as they are nearer being melted; ſuch as Gold, Silver, *&c.*

45. Lead, and all its Products, turn into Glaſs by a great Fire (§ 9, and 38.)

46. This Glaſs or Litharge pounded together, and melted with vitrificable Stones, (§ 29), makes them turn into Glaſs with a much leſs Fire than they would have done by themſelves. If you add a ſufficient Quantity of Litharge, theſe Stones melt into a kind of Glaſs ſo very attenuated, that it inſenſibly perſpires through the Veſſels; nay, it melts the Veſſels themſelves, when they yield not a free Paſſage to it.

47. All Lime-Stones (§ 30), if uſed in the ſame Manner (§ 46.) and mix'd with Litharge, have the ſame Fate, but they require a much greater Quantity of Litharge, to acquire the ſame Degree of Fluidity, when melted.

48. Stones that keep unburnt in the Fire (§ 31.) are more difficult to be changed; and unleſs ſome mechanical Mixture is uſed, and a moderate Fire preſerved a long while, the Litharge vaniſhes through the Veſſels that contain it, before it has perfectly melted theſe Stones.

49. Among Metals, Litharge likewiſe facilitates the Fuſion of Copper and Iron by Fire, but at the ſame Time it conſumes a conſiderable Quantity of them, and runs itſelf with them into Glaſs, as is plain (§ 46.) from what has been ſaid. But the Glaſs of Lead does not mix as much with theſe Metals before they are deſtroyed, as it does with the aforeſaid Stones; but ſwims about and upon them.

50. Tin and its Calx (§ 10, 41.) is with great Difficulty vitrified by a Mixture of Litharge, for it, always ſeparating from it, ſwims upon it. But, if it turns into Glaſs at laſt, it preſerves a certain Clammineſs, not to be taken away except by a conſiderable Addition of Litharge. The Vitrification of its Calx is in ſome Degree promoted by Copper: Which being added to, and melted together with it, makes it more eaſy to be conquered.

51. The melting of Gold and Silver is likewiſe haſtened by Glaſs of Lead (as § 49.) and they loſe nothing by it. However, if Gold and Silver are very frequently melted with Litharge, they at length prove

to have loſt a Trifle of their Weight: Nor are they, for all that, deſtroyed of that Quantity, for it may, by a plain Separation, be extracted again out of the Litharge, and will then be found of the ſame Nature as before: As the Operations in our ſecond Part will ſhew.

52. The melting of Semi-metals is alſo promoted by a Mixture of Litharge; and then it happens with them as with leſs perfect Metals: Which is facilitated by an Addition of Iron.

53. Therefore it is ſelf-evident of what great uſe this Litharge is in roaſting refractory Ores of Gold, Silver, and Copper. For it melts any Stones and Earths whatſoever, with more Swiftneſs, than it turns Metals into Glaſs, provided every thing be equally and minutely mix'd. Then the Metal which is heavier goes down through the Glaſs, which is in a thin Fluxion, and gathers into a *Regulus*, upon which a few ſmall earthy *Scoriæ* are ſwimming. But there is always a Part of the Metal deſtroyed at the ſame Time: Or, if it is Gold or Silver, a ſmall Quantity of it is detained in the *Scoriæ*.

54. But, as the Litharge penetrates through any Veſſels whatever, and, while melting, riſes into a Scum, and thus eaſily overflows; Aſſayers never uſe it alone, but communicate a Clammineſs to it, and fix it by adding a certain proportionable Quantity of Flints, Sand, Clay, *&c.* for they take of Powder of calcined Flints, or of Sand one Part, of Litharge two Parts, which they mix very exactly by pounding them together; to this they add Nitre or common Salt, that the whole may melt more eaſily; they ſhut the Veſſels, which muſt be thick and ſolid, with a ſmall Cover cut cloſe, leſt the Coals which are to reduce the Litharge into Lead, ſhould fall into it; they leave it thus melted for above a Quarter of an Hour and more; during which Operation they muſt be ever looking into the Aſh-Hole of the Wind-Furnace, to examine whether the Crucible holds the Glaſs or no. For it moſt frequently happens, that it perſpires

through the Crucible like Water, and falls down in Drops into the Aſh-hole: when you ſee this, you muſt immediately take the Veſſels out of the Fire, if you are not willing to loſe all. Having broken the Crucible, you moſt commonly find a ſmall *Regulus* of Lead, reduced by the Fatneſs of the Salt, or of the impure Nitre: In the Middle is the Glaſs of Lead, which is to be ſeparated and kept for uſe, the ſaline Cake which is at top muſt be thrown away.

55. If you uſe Clay or Potter's Earth, or the *Caput Mortuum* of Vitriol waſh'd, you make likewiſe excellent Glaſs with Litharge; only you are to take care not to add too great a Quantity of theſe Things; for when Litharge is too much ſaturated, it cannot conſume the Bodies to be ſaparated from the Metals. The Glaſs likewiſe becomes uſeleſs, when Part of the Litharge runs through the Veſſels. This Damage proceeds either from the Crucible's not being ſolid enough, or from the mechanical Mixture's having been neglected.

56. Moreover, it is to be noted concerning Lead, that its Vapour, if it touches even the beſt Gold, renders it brittle.

Of TIN.

57. See the Deſcription of it (§ 10.) Tin eaſily melts with Silver, Gold, and Copper; but when they are melted with it in equal or leſs Quantity, it renders them extremely brittle; eſpecially Silver, which becomes as brittle as Glaſs by the leaſt Mixture of Tin. But if a much greater Quantity of it enters into metallick Maſſes, theſe ſtill preſerve ſome Pliantneſs: For inſtance, ten Parts of Tin and one Part of Copper melted together make a Maſs more rigid than pure Tin, but which is ſtill ſomewhat tractable: By this Artifice, they make Utenſils of Tin that are much more durable. If you add to Copper ten Parts of Tin, and a little Braſs or *Zink* together, this will produce a brittle and very ſonorous Metal, fit for making of Bells and Cannons.

58. Lead is of all Metals that which acquires leſs Brittleneſs by being mix'd with Tin: Though it becomes ſomewhat more rigid.

59. Filings of Iron, or very thin *Laminæ* of it, being preſently made red in the Crucible, if you pour upon them the double Quantity of Tin, on a great Fire, they will turn into a brittle white *Regulus*, yielding quickly to the Attraction of the Load-Stone. And here you muſt have a very quick Fire, leſt too great a Quantity of Tin ſhould be conſumed. In order to which, and for the quicker melting of the Iron, it will be proper to add a Quantity of Argol, that is the crude Tartar of Wine, and Glaſs.

60. The Vapours of *Tin* are infinitely noxious to *Silver*, *Gold*, and *Copper*; as they render them brittle: Nay, if you ſprinkle ever ſo little *Tin* in the Fire where theſe Metals are to be put, the moſt ductile of them, being made red on ſuch a Fire, becomes ſo very untractable, that the leaſt Touch of a Hammer will make it ſplit like Glaſs. Therefore, if the ſmalleſt Quantity of Tin ſhould happen to fall into the Fire; the whole muſt be taken out of it with great Care, and the Fire be made once or twice ſtronger; that whatever Part of Tin remains, may be entirely diſſipated.

Of COPPER.

61. Copper, melts together with Silver and Gold, witneſs all our Coins and Utenſils, and makes them harder; whereas they could hardly otherwiſe be applied to any uſe in common Life, on account of their great Softneſs.

62. Copper put on the Fire with Iron, promotes the melting of the latter: However it becomes itſelf more rigid and more pale by this Mixture. But it will be proper, in order to make this melting more ſucceſsful, to throw upon it as much Tartar and common Glaſs, as would be neceſſary to cover the Surface of the whole Maſs.

Of

Of GOLD *and* SILVER.

63. Gold and Silver mutually melt with one another, and are beſides eaſily mix'd with Iron. As to their other Properties, I ſhall refer you back to what has already been ſaid.

Of IRON.

64. See what was ſaid before. However, it is obſervable that Iron muſt be extremely pure in theſe Mixtures; for if it contains too much *Sulphur*, the melting does not ſucceed ſo well; and the Iron gathers into a *Regulus* ſeparated from the other Metals.

Of MERCURY.

65. *Mercury* mixes with Gold, Silver, Lead, Tin, Zink, and Biſmuth; but not quite ſo eaſily with Copper. This Solution is called *Amalgamation.* But all theſe *Amalgama's* become white, and, when a great Quantity of Metal is diſſolved in *Mercury*, they thicken into a kind of Paſte. But the following Conditions are required, for the quick and good Succeſs of theſe Mixtures.

Firſt, That the Metal be comminuted, which may be done any way, provided there is no Alcali in the Operation; becauſe this either retards, or totally hinders, the Action of the *Mercury.*

Secondly, That a mechanical Mixture be employed by grinding in a Mortar.

Thirdly, That the Heat be as great as the Mercury can bear without being diſſipated.

Fourthly, That the Surface of the Metal be very clean, and above all free from Greaſineſs.

66. But there is a greater or leſs Quantity of the ſaid Metals diſſolved, according as the Conditions already mentioned are not wanting, and the Pureneſs of the *Mercury* is greater or leſs.

67. However, you muſt take care, that a Part of the diſſolved Metal be ſo perfectly attenuated by the *Mercury*, that it may inſinuate through the Pores of a Filtre, as Salt diſſolved in Water. However it is

but a very ſmall Quantity that can be thus diſſolved; a certain one cannot be univerſally determined, ſince it muſt be found out by a very gentle Diſtillation, in Experiments made on purpoſe. The other Part of the diſſolved Metal runs freely with the *Mercury:* But if the *Amalgama* is ſtrained through a Glove-leather Purſe, the Metal is retained in it, imperfectly diſſolved, together with about an equal Quantity of *Mercury* adhering.

68. Mercury has no Power on Iron and *Regulus* of Antimony; or, if it has any, it muſt be exerted by an Artifice which has been hitherto a Secret to us.

II. *Of* SEMI-METALS, *conſidered as* Menſtrua.

Of ARSENICK.

69. Arſenick, the Deſcription whereof was given (§ 17.) well pounded and mix'd together with ſeveral Earths, eſpecially with ſuch as are calcareous and not to be affected by the Fire, being expoſed to the Fire, proves much more fixt than it is of itſelf.

70. If to the Mixture (§ 69.) is added a little *Tartar*, and it be then lightly moiſtened with Water, and preſſed down with ſmall Plates of Iron interpoſed every where, in a Veſſel, able to reſiſt the greateſt Fire; and if finally, the Veſſel being well cloſed with only a ſmall Aperture left to it, is expoſed for ſix or eight Hours, firſt to a moderate Fire encreaſed at laſt to the higheſt Degree, ſo that the Maſs within may be melted; the whole proves a white brittle *Regulus* of Iron, not to be reduced to its former State, except by an open Fire, continued very long.

71. If Copper is managed in the ſame manner with Arſenick, it acquires the ſame Whiteneſs, and retains in good part its Malleability: Eſpecially, if it is once or twice melted with *Tartar* and *Borax*, that the ſuperfluous Arſenick ſtill inherent may be diſſipated.

72. Tin and Arſenick, mixt over the Fire, turn immediately to Aſhes, the Part of the Arſenick adhering ſtrongly enough to the Tin.

73. Lead mix'd with Arſenick is immediately and partly carried away, in the Form of a thick Smoak, the reſt being a thin Glaſs of a Saffron colour.

74. Silver is penetrated by Arſenick applied in the ſame (§ 70.) manner, and loſes its Malleability; but it vaniſhes away by a great Fire, in the Form of Smoak.

75. Gold, penetrated by Arſenick, becomes infinitely brittle, it loſes its Colour, and then being ſuddenly thrown in a great Fire, Part of it is ſublimed.

Scholion. *Arſenick, on account of this Property, is called* Sulphur rapax: *Becauſe, by its Action excited with Fire and Air, there is often a greater Quantity of Metals raiſed and ſublimed in form of Flowers up the Furnaces, than is collected in the very melting Pots of the Furnaces themſelves. However, the ſolid Matter thus ſublimed is called* Cadmia fornacum.

76. Finally, *Arſenick* is attracted with a different Force by different Metals, and attracts them reciprocally. Of all Metals it abſorbs *Iron* moſt greedily, and ſucceſſively *Copper*, *Tin*, *Lead*, and *Silver*. Therefore all Metals may be freed of the Foulneſs of *Arſenick* by *Iron*, but not ſo well by *Scoriæ* of *Iron*, unleſs the Fuſion be made in an open Fire: For then *Scoriæ* may be uſefully imployed, becauſe, though they do not of themſelves abſorb the *Arſenick*, they nevertheleſs being reduced to *Iron*, act in the ſame Manner as *Iron* itſelf. Now we ſhall ſoon ſhew, that they may be reduced to it, by the means already mentioned.

Of ANTIMONY.

77. The *Regulus* (§ 16.) of *Antimony*, when melted by a great Fire, proves totally volatile. In the Fire, it bubbles almoſt like *Lead*, and diſſolves into a kind of Glaſs not very fix'd, while the reſt vaniſhes into Smoak.

78. The ſame renders all Bodies hitherto known volatile, Gold on certain conditions excepted.

but a very [illegible] not very fine, it turns into a
a certain [illegible] Fire, which *Calx*, being
it muſt [illegible] turns entirely into a kind of
Experi[illegible] dark red Colour, half tranſpa-
the di[illegible] hard. This Glaſs has a greater
But i[illegible] than *Litharge* itſelf (§ 46.--52.)
Leather [illegible] Stones of all kinds, diſſolves them,
diſſol[illegible] ſtrong open Fire carries them away
of M[illegible]

6[illegible] Glaſs does not equally change all Me-
of A[illegible] into *Scoria*, and makes them vo-
an A[illegible] excepted; Becauſe it is thereby
[illegible] geneous Matters, except of *Silver*
II. [illegible] Separation is more difficult to be ob-
[illegible] way; you may therefore with Reaſon
[illegible] Wolf and Devourer not only of Metals,
[illegible] almoſt all Bodies.

[illegible] ever, this Action (§ 80.) of the reguline
[illegible] *Antimony* is greatly augmented, if you uſe at
[illegible] ſtrong Fire with Veſſels well cloſed, or throw
[illegible] any kind of Fat whatever: For by theſe
[illegible] you hinder the *Regulus of Antimony* from evapo-
[illegible] immediately, and its Virtue to deſtroy Bodies
[illegible] longer Duration; ſo that at laſt every thing va-
[illegible] and is conſumed by a ſtrong and open Fire.

However, the *Regulus of Antimony* unites as vari-
[illegible] with different Metals, as was ſaid (§ 76.) *Arſe-*
[illegible] did; for it greedily incorporates with *Iron*, and
next with *Copper*, &c.

Coroll. Hence appears how near of kind *Regulus of Antimony* is to *Arſenick*: For the whole Difference ſeems to be, that *Arſenick* is fix'd in *Antimony* by a vitrifying Earth. Whence it happens that when *Antimony* is mix'd with Metals, it can hardly be conſumed from thence by Uſtulation only: Nay, when being expoſed with them to the open Fire, it evaporates; it in the mean while deſtroys the metallick Particles, as ſoon as it renders them volatile.

Of

Of BISMUTH.

83. *Biſmuth* (§ 15.) cauſes the leſs fuſible Metals to melt, by a much leſs Fire than they would, if they were to be melted ſingle: It mixes eaſily with them all, and according to the greater or leſs Quantity of it added to them, it renders them more or leſs white, brittle, and Semi-metal-like.

84. But *Biſmuth* being ſo eaſily deſtroyed, it is proper that the Mixture of it with Metals difficult to be melted, be made in cloſe Veſſels, that the Fire be inceſſantly increaſed, and the other Conditions fulfilled, which are mentioned (§ 59.)

85. It is very obſervable, that *Biſmuth*, melted with *Lead*, *Tin*, or *Silver*, diſpoſes them ſo, that, being afterwards amalgamated with *Mercury*, they are infinitely more attenuated, and paſs through the Leather together with the *Mercury*, in much greater Quantity than they would if there was no *Biſmuth* (§ 67.)

Of ZINK.

86. *Zink* (§ 14.) mixes eaſily with *Lead* and *Tin*, and, according to its Quantity, renders them leſs malleable.

87. He that is willing to melt *Zink* together with Metals not very fuſible, muſt uſe the Methods preſcribed (§ 59.)

88. When it is by Fuſion mix'd with four Times the Quantity of Copper; it becomes a brittle Metal, of a fine Gold-Colour, called *Prince Rupert's Metal*, *Prince's Metal*, or *Bath Metal.*

89. It is moreover obſervable, that *Zink* is very rapacious: Which Quality of it is not ſo eaſily corrected by an Addition of *Iron*, as is in the foregoing Semi-Metals. For, by the Help of a greater Fire and of Air, it ſublimes all mix'd Metals; ſo that they adhere to the Furnaces and Stoves in form of Flowers,

(which then are called *Nil album vel griſeum Pompholyx.*) Or go away together, in form of Sublimate, called *Tutty* or *Cadmiæ fornacum*, in *German (Offenbruch)* infinitely various in Colour, Weight, Figure, and Confiſtence.

Scholion. *But the foregoing Semi-Metals produce likewiſe the ſame Flowers and Sublimates, though without the Aſſiſtance of* Zink: *On which Account the ſaid Sublimate and Flowers are of various Kinds. However, wherever theſe are produced, they are always Indications of ſome thing of the Arſenical or the Semi-metallick Species. On the ſame Account they differ much from each other: For ſome of them adhere to the very Sides of the Furnaces, in ſpite of a great Fire; and ſome others prove incapable of reſiſting a leſs Degree of Fire, even in the higheſt Chimneys.*

Of pure ſulphureous or oily Bodies, conſidered as Menſtrua.

90. Imperfect Metals, ſuch as *Iron*, *Copper*, *Lead*, and *Tin*, change their Form, loſe all their Malleability, and part of their Fuſibility, by a long and ſtrong Calcination, and of Conſequence loſe their metallick (§ 5.) Nature. Semi-Metals, Arſenick excepted, by a like Calcination, diſſolve into *Calxs*, which by a ſtrong Fire (§ 8. *Schol.*) turn to *Scoriæ*, or become volatile.

91. If you add to theſe *Calxs* (§ 90.) a ſulphurous (§ 24.) Body, without any vitriolick (§ 22.) Acid, and ſo fixt of its Nature as not to be diſſolvable by any but a great Fire; the brittle *Scoriæ*, or the *Calx* is reſtored to its Priſtine, either Metallick (§ 5. or Semi-metallick State (§ 13.); which Operation is called Reduction.

92. This reduced Metal or Semi-metal may, by repeating the Calcination, again be deſtroyed (§ 90) and in the ſame Manner (§ 91.) be reduced to a like *Soria*, or a like *Calx*.

93. Hence it is plain, that the *Oleoſum purum Principium*, or a pure oily Principle, enters into the Com-

poſition of Metals and Semi-Metals; which may be ſtill more confirmed by an Addition of Nitre. For if the Nitre, which detonates with every ſulphurous Matter, is caſt upon Metals grown red hot in the Fire; theſe Metals, under a very evident Detonation, immediately change into *Calxs* and *Scoriæ*; becauſe without Nitre they never undergo ſo ſudden a Change, in the ſame Time and Degree of Fire.

94. But the Chemical *Analyſis* ſhews us, that there is a ſulphurous or oily Principle of this Kind (§ 24.) contained in every part of Vegetables and Animals; ſince a great Quantity of it may be extracted thence, by a ſtrong Diſtillation.

95. However, it is obſervable, that *Calxs* and *Scoriæ* (§ 90, 91, 92, 93.) are never ſo far reduced by ſulphurous or oily Matters, as to be by them reſtored to their former Quantity. Nay, there is always a part of them deſtroyed: Which Loſs does likewiſe vary, according to the Diverſity of the Metal or Semi-Metal employed, or to the Duration and Violence of the Fire, by which the Calcination has been made; according to the quicker or ſlower Reduction of the *Calx*, and to the greater or leſs Purity and Fixedneſs of the oily Matter itſelf, wherewith the Reduction is made.

Corollar. I. From theſe Things appears the Reaſon of the Extraction by Fire of the Metals, Iron, Copper, *&c.* out of their Marcaſite. For, if they are laid in *Strata* together with Coals, and then urged by a very ſtrong Fire, excited with a Pair of Bellows, their *Scoriæ* melting, running between the burning Coals, and extremely attenuated by the Fire, is impregnated with the oily Exhalation of the burning Coals, and thus reduced to a metallick Form.

Corollar. II. As the *Calxs* of Metals melt in the Fire, with much greater Difficulty than the Metals themſelves, whoſe Deſtruction gave them Birth; the Reaſon is plain, why a much greater Fire is neceſſary to reduce Metals and Semi-Metals from their

Calxs

Calx to their former State, than to melt the ſame after their Reduction.

Corollar. III. For the ſame Reaſon, the fatty Matters added to Metals in order to melt them, put them ſooner in Fuſion, than the ſame Degree of Fire could have done, without the immediate Touch of oily Bodies.

Corollar. IV. It is likewiſe evident, why Metals and Semi-Metals, that are deſtructible by a naked Fire, are much leſs deſtroyed, when they melt under the Duſt of Coals, or ſome other phlogiſtick Body, than if they alone and naked ſuſtained the Strength of the Fire.

Of SALTS, *conſidered as* MENSTRUA.

Of fixed Alcaly, *conſidered as a* Menſtruum.

96. See the Characteriſticks of this Salt. *Boerh. Elem. Chem.* T. I. p. 764.

97. *Alcaline Salt* diſſolves *Stones* and *Earths* of all Kinds, in a great Fire, eſpecially thoſe that vitrify: Which is the ſooner effected, as the Mixture was more exactly made before. Then a Glaſs is produced, which is extreamly various, according to the Diverſity, Tranſparency, Hardneſs, Weight, Colour, and Fuſibility in the Fire, of the *Salt* and *Stones*.

98. Gold and Silver, by the Help of this Salt, caſt only upon them, are eaſily melted, and loſe nothing, provided both the Metals and Salt be perfectly pure. But if the *Calx*, Filings, &c. of theſe Metals, mixt with a greater Quantity of Alcaline Salt, melt in the Fire; the whole Metal does not ſink to the Bottom, but a part of it is detained in the Salt ſwimming at Top. But when the Earths and Salts are mixt with them at the ſame Time, the *Lentor* or Softneſs by the Earth communicated to the Salt, and which no Fire can perfectly attenuate, cauſes the Quantity of Metal in them remaining to be conſiderable.

99. Iron, Copper, Tin, and Semi-Metals, being melted with this *Salt* of Oil made very ſharp, are more ſlowly conſumed. Beſides, *Alcali* promotes very much the melting by Fire of Iron, Copper, and the *Regulus of Antimony*: But not that of Tin, *Lead*, *Biſmuth*, and *Zink*; as theſe melt eaſier than *Salt* itſelf.

100. *Mercury* reſiſts *Alcaly* altogether, nor can it be mixt with it by any Method that is known. This therefore is to be entirely avoided in the Preparation of Metals from an *Amalgama* (§ 65).

101. What kind of fixt Alcali, whether mixt with pure oily Matter, or with mineral Sulphur, is to be preferred, we ſhall point out hereafter, when we treat of compound *Menſtrua*, *Flux's Cements*, *&c*; having hitherto explained only the ſimpler Species of them.

102. But the fixt Alcali, being, as it were, a dry *Menſtruum*, ſerves chiefly to reduce the *Calx* of Metals, that have been reduced by Acids. For Acids, adhering to Metals, and being driven away violently bya Fire carried to an exceſſive Degree; they hurry a conſiderable Quantity of them away with themſelves: And if they are obliged, by adding more of the fixt *Alkali*, to paſs firſt, whatever metallick Matter they carry with them is abſorbed and fixt: that by this Means the *Calx* of Metals, made intirely volatile by *Acids*, eſpecially by that of Sea-Salt, may be reduced without Loſs: Which cannot be conveniently effected by adding other *Menſtrua*.

103. There is hardly any Neceſſity here to mention the volatile Alcali; it being very ſeldom, if ever, neceſſary in aſſaying.

Of ACIDS, *conſidered as* Menſtrua.

104. *Acids* are employed by Aſſayers, either the moiſt or the dry Way, and according to the ſeveral Methods uſed, produce different Effects. Among theſe Acids occur, 1^st, The vegetable Acids, of which

[illegible] The [illegible] Acid of Vitriol [illegible] be there produced with [illegible] Art of Chemiſtry, [illegible]

[illegible]

[illegible] upon Earths and [illegible], or [illegible] to a [illegible] Likewiſe totally [illegible] and not to be affected [illegible] the vitrificable Stones, thoſe [illegible] and all the others belonging [illegible] do entirely reſiſt Wine- [illegible] at leaſt as to their vitrificable [illegible] its Power.

[illegible] Metals and Semi-Metals, Copper, [illegible] moſt readily with Vinegar. [illegible] It has no manner of Power on [illegible] Mercury. The others are more [illegible] than diſſolved by Vinegar. [illegible] Diſſolutions (§ 105 and § 106.) ſuc- [illegible] Heat than in the Cold. The [illegible] of all the other following *Menſtrual* [illegible]

Of the *Acid of* VITRIOL.

[illegible] Acid of Vitriol (§ 22.) has, with Earths and [illegible] the ſame Virtue as Vinegar of Wine (§105.) [illegible] Among Metals and Semi-Metals it diſſolves [illegible] Zink, Iron, and Copper; and even Iron with an Exhalation ſmelling very unpleaſant, to which Fire muſt not be ſuffered to approach, if the Diſſolution is made in a Veſſel that has a narrow Neck: For it takes Fire, and burſts the Veſſels with great Violence.

110. *Silver*, *Mercury*, *Lead*, and *Tin*, are, in the Heat of the Ebullition, rather corroded than diſſolved by this moſt concenerated Acid. Though ſome of them be at the ſame Time ſo far diſſolved, as to paſs through a Filtre, and may be waſhed with Water.

111. Gold is almoſt quite free from the Action of this Acid.

Of AQUA FORTIS.

112. Aqua Fortis and Spirit of Nitre are the ſame, and differ only by the Manner in which they are made. For the former is diſtilled with Vitriol and Colcothar, and the latter with Clay, Bole, Oil of Vitriol, Brick-duſt, *&c.* But the generality of Aſſayers uſe Aqua Fortis, as being more eaſily prepared; becauſe a Quantity of Vitriol, much leſs than the terreſtrial Mixtures juſt mentioned, with leſs Fire alſo, expels the Spirit out of the ſame Quantity of Nitre. This Diſtillation of Aqua Fortis is made as follows.

113. You put Vitriol in an Earthen or Iron Pot: If you make a Fire under it, the Vitriol begins to melt and ſmoke; by increaſing the Fire gradually, it thickens and aſſumes the Aſh-colour. Let it be then ſtirred with a Twig juſt before it becomes ſolid, till it be perfectly dry: But let it be taken as yet boiling out of the Pot: For if it grows cold therein, it will ſtick to it ſo faſt, that you will hardly be able to get it out. Pound in a moſt ſubtil Powder three Pounds Weight of this calcined Vitriol, and mix them perfectly with four Pounds of Nitre well dried, and pulverized extremely fine. Put all theſe together in a Cucurbite, a Retort, or an Iron Pot, and then put it in a Furnace, that ſhall be deſcribed in our Chapter of Utenſils, where the reſt of the Apparatus hereto belonging will likewiſe be explained.

Let then the Fire be made, at firſt not much greater than is neceſſary to make Water boil. When the Recipient begins to grow warm, then continue the ſame Degree of Fire, till all the *Phlegm* is expelled, which you will know from the Diminution of the Heat of the Recipient; then increaſe the Fire gradually, till you ſee a few ſlight yellowiſh Vapours riſe. Keep up the ſame Fire for one or two Hours, and finally make it ſuch as may warm the Veſſels moderately; having continued it ſo for ſome Hours, let the Veſſels wax cold, pour the Liquor, now emitting reddiſh Fumes, out of the Recipient into a Glaſs Veſſel, having a Glaſs Stopple, and this Liquor thus prepared is your *Aqua Fortis.*

Scholion. I. *In this Operation, you muſt always proportion the Duration of the ſeveral Degrees of your Fire, to the Quantity of the Matter to be diſtilled.*

Scholion. II. *Obſerve beſides, that, for Security's Sake, you are to leave, in the Cloſure of the Recipient and Veſſel which contains the Matter to be diſtilled, a Hole that may be ſtopt and opened with a Wooden Peg: For if you happen to exceed the juſt Degree of the Fire, eſpecially when, in the beginning, the firſt and more ſubtile Spirits, which are very elaſtick, come forth; the opening of this Hole may give them a Paſſage, leſt the Veſſels ſhould burſt, which would be vaſtly dangerous.*

114. This Operation requires Nitre perfectly pure, that you may have true Aqua Fortis. Above all Things, you are to avoid the leaſt Mixture of Marine Salt, for the Reaſon hereafter to be mentioned, when we treat of *Aqua Regia.* Mean while, as this Operation is very toilſome, and takes a very long time; I ſhall hereafter give a Method for making *Aqua Fortis* of the requiſite Purity, and diſtilled out of a Nitre not even perfectly pure.

115. There are beſides many other Ingredients, commonly uſed in the diſtilling of *Aqua Fortis:* viz. burnt Allum, Sand, and the like; which are here added, to hinder the Species, which may happen not to be ſufficiently calcined, from foaming, and from breaking the Veſſel with great Violence. But when theſe Species are ſufficiently calcined, and dried up;

then theſe Additions are perfectly needleſs, and by over-ſwelling the Maſs to be diſtilled, requires Veſſels of a much larger Size.

116. Nay, there are beſides many other, partly needleſs and partly noxious, Ingredients uſed by Diſtillers of *Aqua Fortis*. Such are Blood-ſtones, unſlacked Lime, Plumoſe Allum, *&c.* all which it is nevertheleſs very proper not to uſe: For they are ſo far from having any good Effects, that they on the contrary yield a much worſe and more expenſive *Aqua Fortis*. This Water therefore muſt never be uſed in docimaſtical Operations, before it has been accurately tried. For indeed *Aqua Fortis* is but too often tainted with theſe heterogeneous Matters, the major Part of it conſumes away, and it is frequently ſo fixt, that the ſtrongeſt Fire is hardly able to take off the leaſt Part of it. I would then here have nothing uſed beſides calcined Vitriol, intimately mixt with Nitre; there being no need of any other.

117. However, Bole, Clay, and Brick-Duſt, do likewiſe expel *Aqua Fortis* out of Nitre, which then is called *Spiritus Nitri*. But you muſt add four Times as much of theſe, in Proportion to the Nitre. Conſequently, this Method is not ſo profitable as the former (§113). as it requires Veſſels conſiderably larger.

118. As the extracted Spirits of Nitre are very difficultly condenſated into Drops, eſpecially in a ſultry Summer's Heat, it will not be improper, on account of the calcined Ingredients, to pour into the Recipient one quarter-part of pure Water, and, what is ſtill better, of Phlegm extracted out of *Aqua Fortis*: By which Artifice the Spirits will be much eaſier received.

119. *Aqua Fortis* diſſolves and corrodes all gritty *Stones*, and the ſeveral Kinds of thoſe that are vitrificable and not conſumed by Fire; but it has no Power on *Flints*, nor of courſe on *Sand*, as this conſiſts of minute Stones of the ſame Kind.

120. It beſides diſſolves *Iron*, *Copper*, *Lead*, *Silver*, *Mercury*, *Regulus of Antimony*, *Biſmuth* and *Zink*; *Tin* imperfectly; *Gold* not at all.

121 Common *Aqua Fortis*, when poured upon *Silver*, moſt generally grows troubled, in the beginning of the Diſſolution; and a little after it is perfect, a Precipitation of a whitiſh Powder is made. If this Powder, taken by itſelf, melts in the Fire with Pot-aſhes, you find at the Bottom of the Veſſel a *Regulus* of *Silver* collected. This ſometimes melts with Difficulty on the Fire, and has all the Characteriſticks of *Calx* of *Silver* precipitated from *Aqua Fortis* by *Oil* of *Vitriol*. This certainly happens, becauſe the *Aqua Fortis* has been extracted by too great and too long a Fire, or becauſe too great a Quantity of calcined *Vitriol* has been uſed, or, in ſhort, becauſe the mutual Mixture of the *Vitriol* and *Nitre* has not been rightly made: For in theſe Caſes, there appear, when the Diſtillation draws at an end, opaque, milky, vitriolick Fumes in the Recipient: Which *Phenomenon* ſufficiently evidences the Cauſe of the aforeſaid Precipitation. The abovementioned *Calx* very ſeldom proves Fluid in the Fire; it afterwards turns into *Horn-Silver*, and ſhews that the impure *Nitre* bought for the Diſtillation of the *Aqua Fortis* was intermixed with marine *Salt*.

122. But as the Diſſolution of *Silver*, eſpecially that by which *Gold* is ſeparated from *Silver* with *Aqua Fortis*, is conſiderably hindered and made uncertain by this Kind of Precipitation (§ 121.); that Part of *Oil* of *Vitriol*, and of *Spirit* of *Salt* which ſpoils the *Aqua Fortis*, muſt be ſeparated: Which is done in the following Manner. They pour one 30th or 40th Part of the *Aqua Fortis* to be purified, into a ſmall Cucurbite, and over a gentle Fire they diſſolve in it *Silver*, in ſuch a Quantity as may fully ſaturate the *Aqua Fortis*. If in the beginning of the Diſſolution the troubled *Aqua Fortis* looks milky, it is judged to want to be purified: Then they paſs through a Filtre the warm Diſſolution, which being clear they

pour drop by drop into the reſt of the *Aqua Fortis* that is to be purified: This will become milky as before; they continue to inſtil the *Aqua Fortis*, till the dropping in of the ſmalleſt Drop doth not at all diſturb it or render it milky: Then they let it reſt for ſome Hours, that the precipitated *Calx* may ſubſide; which done, they again let a Drop fall, and repeat it conſtantly, till at laſt the milky Cloud is no longer produced by the Falling of the Drop. Finally, they decant the pure and limpid *Aqua Fortis*, from the *Calx* which ſubſided at the Bottom; or they ſtrain it gently through a fourfold filtring Paper, which ought to be ſmall, leſt it ſhould break, by being overloaded with too much of the *Aqua Fortis*. The remaining *Calx* is ſuch as was mentioned (§ 121.) but the *Aqua Fortis* is perfectly purified.

Scholion. *Some are uſed to employ common* Silver *mixed with* Copper, *nay* Copper *itſelf, for the precipitating of the Spirit of marine or vitriolick* Salt *from* Aqua Fortis: *But this does not at all ſucceed, when Spirit of marine* Salt *is to be precipitated, becauſe this being mixed with* Aqua Fortis *diſſolves* Copper *perfectly. The* Oil of Vitriol *is indeed driven out of* Aqua Fortis, *by means of the* Copper, *in form of a whitiſh* Duſt; *but not ſo perfectly as by* Silver. *Otherwiſe, it appears in this Operation that the precipitating Body adheres to that to be precipitated, and ſinks to the Bottom together with it.*

123. The beſt *Aqua Fortis* is often tinged with a greeniſh Colour: Which happens, if *Aqua Fortis* having been expoſed for ſome Days to the open Air, and thus deprived of its fuming red Spirit, you pour upon it ſome freſh ſtrong *Aqua Fortis* ſtill emitting its Fumes; or if *Aqua Fortis* is diluted with Water. But that you may be certain that this Colour does not proceed from *Copper*, pour a little of the Liquor into a ſmall Cucurbite, and add to it as much of an alcaline Diſſolution or Spirit, as is ſufficient to ſaturate the Acid: Then, if there is ever ſo little *Copper*, the Colour becomes of a very dark Azure, with a cloudy Precipitation; becauſe the *Nitre* has been thereby

regenerated, which does not diſſolve *Copper* ſo much as *Aqua Fortis* does: But if there is no *Copper*, the Colour vaniſhes entirely.

124. *Aqua Fortis* thus prepared (§ 113. and 117.) and corrected (§ 122.) muſt be concentrated to a certain Degree: For if it is too week, it either retards the Diſſolution, or often does not even affect the *Silver*. If, on the contrary, it is too ſtrong, it vaniſhes into Fumes, which ruſh violently out of the Veſſels, though ſufficiently deep, hurrying part of the *Silver* along with them: But if there is any thing of *Gold* in the *Silver*, it is corroded into a *Duſt*, the perfect Collection of which is afterwards very difficult. The firſt Fault is remedied, by pouring the *Aqua Fortis* into a deeper Cucurbite, and by abſtracting Phlegm out of it, over a gentle Fire, till you ſee yellowiſh Fumes appear. But, to find out whether it is too ſtrong, you are to uſe the following Method. Melt together one Part of *Gold* and Four Parts of *Silver*; of which make a Plate, which you are to cut into three or more Parts; roll up each Part, that it may more conveniently be introduced into a ſmall Cucurbite: When rolled up, and ſlightly heated at the Fire, put this ſmall Plate into the ſaid Cucurbite, pour upon it *Aqua Fortis*, about the Triple of the Weight of the Metal, and put it on a gentle Fire: If then the *Silver* is eroded from the *Gold*, ſo that the *Gold* remaining retains the very ſame Figure of the Plate rolled up, and there appears no reddiſh *Duſt* at the Bottom of the Veſſel, then the *Aqua Fortis* has its proper Degree of Strength: But if the Diſſolution has been made with ſo much Violence, that the Powder of the *Gold* was eroded, or the Plate almoſt broken, the *Aqua Fortis* is too ſtrong. You muſt then, in this Caſe, dilute it with one tenth or eighth Part of pure Water, or rather of weaker *Aqua Fortis*, if you have it at hand, or of the Phlegm that was drawn from it: Which done, you muſt repeat the Trial of the Diſſolution of a like ſmall Plate, ſeveral Times over, till the *Silver* be diſſolved without the

leaſt Diminution in the *Gold*, whereby you may be ſure of the requiſite Degree of Strength in your *Aqua Fortis*.

125. *Aqua Fortis* is excellent, when it comes again after having been by Fire expelled out of diſſolved Metal; becauſe it may be almoſt entirely fetched out of it by Diſtillation. In order to this, you introduce into a middle-ſiz'd Glaſs-cucurbite, adapted to an Alembeck, with an Hole in it, one Pound or one half Pound of the ſame Diſſolution, and diſtil it in the Manner hereafter deſcribed in the Article of Utenſils, into a large Recipient; that the Drops may fall one after another at the Interval of ſome Seconds: When the Phlegm of what remains ſhall be drawn off to ſome Ounces; let a like Quantity of a freſh Diſſolution, gently warmed, be put a-new into the Cucurbite, and be drawn off again; and let the pouring on of the freſh Diſſolution be reiterated in the ſame Manner, till it is all grown thick. This muſt be done in a ſmall Cucurbite, ſeveral Times over; leſt a large Veſſel, being over-charged with too great a Quantity of the Diſſolution, ſhould burſt all of a ſudden, and the *Aqua Fortis* and Metal be loſt at once. When, after the extracting of all the Phlegm, yellowiſh Fumes begin to appear by increaſing the Fire a little, let a Drachm or half a Drachm of Suet be added, leſt the remaining Metal, being dried up, ſhould ſo ſtrongly adhere to the Sides of the Veſſel, as that it could not be taken off: And when at laſt the Maſs ſhall be quite dry, let it be put on the Fire, till it becomes red hot. The *Calx* of Metal, which remains at the Bottom of the Cucurbite, muſt be collected, and melted with Pot-aſhes.

Of Spirit of common SALT.

126. Spirit may be extracted out of *common Salt* (§ 20.) after the ſame Manner (§ 113. and 117.), as it is out of *Nitre*: However, the Diſtillation of it requires a Fire much ſtronger, and much longer conti-

nued,

nued, than that of *Spirit of Nitre.* It comes out in the Form of ſmall whitiſh light Clouds, which coagulate into a yellowiſh green Liquor. But this *Spirit* may be much more conveniently produced with *Oil of Vitriol*; by pouring one part of this *Oil*, diluted with an equal Quantity of Water, upon two Parts of *common Salt*: and then you make the Diſtillation out of Glaſs-Veſſels, in a Sand-Bath. Spirit thus drawn, more diluted, and then diſtilled by a gentle Fire in a Cucurbite, from a Quantity of the pureſt *Sea Salt*, in order to abſorb the Portion of *Oil of Vitriol*, which may happen to adhere, and then dephlegmated and rectified; I ſay, ſuch Spirit muſt be looked upon as the beſt *Spirit of Salt*.

127. *Spirit of Salt* diſſolves *Iron* into a yellowiſh green Liquor, and *Copper* into one of a deep yellow Colour. *Tin* diſſolves in this Spirit with Violence and much Noiſe, in great Plenty, and becomes a thick, tranſparent Fluid. *Lead* diſſolves in it likewiſe; but after it has reſted a while, there is always ſomething of a white Duſt that ſinks to the Bottom. *Silver*, provided it be very pure, does not diſſolve in *Spirit of Salt*; but if it contains ever ſo little *Copper*, for it ſeldom is altogether free from it, its Surface is in a Manner corroded by the Acid of *Salt*, and its Colour ſullyed. The beſt *Spirit of Salt* prepared with *Oil of Vitriol*, and rectified (§ 126.), being poured upon *Gold* does not influence it in the leaſt. It diſſolves *Mercury* into a limpid Liquor. When more diluted with Water, it does not diſſolve *Regulus of Antimony*: But this being diſſolved in the moſt concentrated *Spirit of Salt*, if you add Water to it, or only expoſe it to the moiſt Air, you reduce it again to a white Duſt. *Zink* diſſolves immediately in *Spirit of Salt*.

Of AQUA REGIS.

128. When the Spirits of *Nitre* (§ 113.) and of Salt (§ 126.) are mix'd together, this Mixture is cal-

led *Aqua Regis*. To have it excellent, put in a Glaſs-Retort *Aqua Fortis* of the beſt kind, well proved, and of the requiſite Strength (§ 122, 124) add to it half the Quantity of common Salt, perfectly dry, and pulverized; and in a Sand-Bath force up the Spirits, firſt by a ſlow, and finally by a ſtrong Diſtillation. Or if you put into *Aqua Fortis* one quarter Part of *Salt Ammoniac*, or of *Spirit of Salt* (§ 126); it immediately aſſumes a yellow Colour, and emits abundantly the white Vapours of the *Spirits of Salt*, which ſoon produces true *Aqua Regis*. However, you are to take Care, in this ſecond Method, that the Veſſel containing the Mixture be not preſently ſhut up cloſe: For in that caſe it would burſt. Beſides, this Mixture muſt be made under the Chimney, leſt the ſuffocating Spirits ſhould ſpread all over, and fill the Laboratory.

129. *Aqua Regis*, diſſolves perfectly *Iron*, *Copper*, *Tin*, *Gold*, *Mercury*, *Regulus of Antimony*, *Biſmuth*, and *Zink*. It even diſſolves *Lead* more than *Spirit of Salt* does; however, it becomes ſomewhat troubled in the Operation. If it has its requiſite Degree of Strength, it does not diſſolve *Silver*: But if you have put in the Mixture a Quantity of *Salt Ammoniac*, or of *Marine Salt*, or of Spirit of common Salt, not ſufficient, it then corrodes *Silver*, nay, it even diſſolves it in part, this *Aqua Regis* being imperfect.

Coroll. The Reaſon is then ſelf-evident, why in the Separation of *Silver* and *Gold* by *Aqua Regis*, it is better to uſe a Quantity of *Spirit of Salt*, or of *Marine Salt*, or of *Salt Ammoniac*, exceeding, than one ſhort of the right Meaſure. Nor is it leſs evident thence, why an exact Separation of *Silver* and *Gold* is better effected with *Aqua Fortis* than with *Aqua Regis*; as the former never corrodes *Gold*, whereas the latter corrodes *Silver* frequently.

Of NEUTRAL SALTS, *conſidered as* Menſtrua.

130. The *Neutral Salts* here chiefly uſed, are *Borax*, *ſel Vitri*, that is, the Scum of Glaſs called by the *Germans Glaſs-gall*, in *Engliſh* Sandiver, *Nitre*, *common Salt*, and *Salt Ammoniack*.

Of BORAX.

131 *Borax*, or *Chryſocolla*, (*Gold-Sodder*) is a Salt very difficult to be diſſolved in Water. It is white, ſomewhat tranſparent, conſiſting of octoëdral Cryſtals; having a ſweetiſh Flavour at firſt, and in the End an alkaline urinous After-taſte. *Borax* expoſed to the Fire, is raiſed into Spume with a hiſſing Noiſe; when at laſt the Veſſel grows red hot, it becomes a thin Fluid, and then growing cold it looks like a very fine Glaſs: However it is at any time diſſoluble in Water, though with great Difficulty.

Scholion. Borax *being ſo apt to foam and ſwell on the Fire, it is very proper to melt it before it is uſed; leſt it ſhould raiſe over the Veſſels.*

132. All Earths and Stones, well mix'd and pounded together with *Borax*, diſſolve into Glaſs of different Species.

133. *Borax* forwards very much the melting of Metals difficult to be put in Fuſion; as are *Gold*, *Silver*, *Copper*, *Iron*, *Regulus of Antimony*, and dimiſhes them very little. When, therefore, Metals are diſperſed, or divided into very minute Parts, retaining however their metallick Form, and are then to be again reduced into one ſingle Maſs by Fire, *Borax* is of very great Uſe. Dirt and Aſhes, though in ever ſo ſmall a Quantity, will certainly hinder ſmall Particles of *Gold* and *Silver* from melting eaſily into one ſingle Maſs. But if they are ſo diſpoſed by a very ſtrong Fire, as to melt into *Regulus*, a great Part of the Metal will always adhere to the ſlighteſt Filthineſs that is flung away. But the viler kinds of Metals not only

undergo the above-mentioned Accidents; but their Surfaces being ſo far encreaſed, *Copper* and *Iron* turn entirely into *Scoriæ* and are deſtroyed, and *Tin* and *Lead* are ſo in great Part. It is therefore very detrimental when theſe viler Metals are mix'd in ever ſo ſmall a Quantity with *Gold* and *Silver*. For in the melting there come upon the Surfaces light *Scoriæ*, in which the *Gold* and *Silver* is retained as in Spunges, and is hindered from running into the *Regulus*. To remove theſe Inconveniences, *Borax* is added, becauſe, as it helps the melting of Metals, and of all Bodies by Fire, its bringing the whole Maſs to a quick Fuſion, cauſes the Metals to ſink to the Bottom without Loſs, and vitrifies the lighteſt *Scoriæ*, throwing them on the Surface. Which is true of both the nobler and the viler Metals, but of *Copper* and *Iron* eſpecially. Beſides, *Borax*, by covering the Surface of Metal tortured in the Fire, as if it were with a kind of very thin *Glaſs*, defends it againſt the combined Force of the Fire and Air, which is very deſtructive of imperfect Metals eſpecially; beſides, that it alſo cauſes Metals to melt in a much leſs Fire.

134. It is likewiſe expedient to rub with *Borax* the Inſide of the Crucibles in which the more precious Metals are to be melted: For they, by that Means, are totally covered with a thin vitreous Cruſt, when in Fuſion, and the ſmall Cavities which never fail to render the Inſide of even the beſt Crucibles, uneven, are filled up: So that the Metal may be poured out all very neatly. Therefore, it is a chief Point never to neglect this Particular, when any little Maſs of *Gold* or *Silver* is to be melted a ſecond Time.

135. Obſerve however, that, if you melt *Gold* with *Borax*, you muſt add to it a little *Nitre*, or *Salt Ammoniac*, but not both together; becauſe they would make a Detonation. For *Borax* alone makes *Gold* pale; but it recovers its Colour again, by means of *Nitre*, or of *Salt Ammoniac*.

136. *Borax*, on account of the above-mentioned Quality (§ 133.) is claſſed, though improperly, among

mong reducing Bodies, that is, among thoſe which reſtore Metals, howſoever deſtroyed, to their metallick Form: For it reduces into one Maſs of *Regulus*, not the deſtroyed Metals, but only the ſcattered Particles of them.

137. There are other neutral *Salts*, uſed for the promoting the Fuſion of Metals: But they are ſeldom alone, and almoſt always mixed with Bodies of the reducing Kind only, of which we ſhall ſpeak ſoon. For theſe alone almoſt always diminiſh ſomething from the groſſer Metals in Fire, or even change them altogether. Of this Kind are *common Salt*, *Sandiver* and *Nitre*. However, of theſe *Nitre* is moſt to be avoided: It is true, it promotes very well the melting of *Gold* and *Silver*; but as it, on the contrary, cauſes a Detonation with the ſulphurous Part of the coarſe Metals, which is not ſo intimately mixed, it changes them into Calxs, moſt commonly very difficult to be melted; which may be eaſily experienced in *Copper*, *Iron*, *Lead*, and *Tin*, mixed with an equal Quantity of *Nitre*, and thrown into a red hot Crucible. *Salt Ammoniack* is alſo now and then uſed by Aſſayers: Though its Defect may be eaſily ſupplied, ſometimes with *common Salt*, ſometimes with *Nitre*. For it ſeldom is uſed, except in the two Caſes abovementioned (§ 128. and 135.) *viz.* For the making of *Aqua Regis*, or for the colouring of *Gold*: And the former may be very well obtained with *common Salt*, and the latter with *Nitre*. For which ſame Reaſon, we have not mentioned *Salt Ammoniac* in our firſt Chapter.

Of SULPHUR, *conſidered as a* Menſtruum.

138. Here we do not underſtand by *Sulphur* any inflammable Matter whatever (§ 24); but that Matter only which is mixed with the Acid of *Vitriol*. Such is *common foſſile Brimſtone*, which, in regard to the Acid mixed with it, has quite other Qualities, than an unmixed oily Principle.

139. The pureſt *Gold*, when melted with *Brimſtone*, remains perfectly the ſame as before; it lets the *Sulphur* burn very freely, remaining itſelf at the ſame Time entire, provided it was very well cleanſed before.

140. *Silver*, when it begins to grow red hot in the Crucible, melts immediately by adding *Brimſtone*, which of courſe renders it more ſpeedily fluid. When poured out, it proves a Maſs that cuts very eaſily, very malleable, of the Colour and Conſiſtence of *Lead*. However, this Maſs, being a ſecond Time expoſed to a very great and long laſting Fire, is again freed from the *Sulphur*, which is then diſſipated; and then it germinates into a kind of woolly Subſtance in caſe the Fire be ſlackened towards the End.

141. *Tin* granulated, and ſtratified with an equal or a double Quantity of *Brimſtone*, deflagrates in the Fire as if *Nitre* had been added, and leaves the fluid Maſs, which becomes ſolid and conſiſtent, while it is yet red in the Fire: Whence it is plain, that the Fuſion of *Tin* is retarded by *Sulphur*. The remaining *Regulus*, under the Hammer, is very brittle, much like a Semi-Metal, and of the Colour of *Lead*. But the Part of the *Tin* thus turned into *Scoriæ*, looks like Aſhes and Duſt at Top, but darker coloured and cleaner within. The whole Maſs of the *Tin* will turn into the like *Scoriæ*, by continuing to burn it with freſh Additions of *Brimſtone*.

142. *Lead* melted with *Brimſtone*, after the Deflagration, turns into a Maſs hardly fuſible by a great Fire, friable, conſiſting of very bright Particles, and with which the Crucible is ſeen to be wholly incruſtated.

143. *Copper* made into Strata with an equal Quantity of *Brimſtone*, melts immediately in the Fire, and turns into a black brittle Maſs. The ſame thing happens when you pour *Brimſtone* upon *Copper* thoroughly red hot.

144. The very ſame Thing happens to *Iron*, which, being taken red hot out of the Fire, and rubbed with *Sulphur*, melts immediately into a ſpongy Droſs. It quits this *Sulphur* with great difficulty, but melts very eaſily with it: So that there is no Metal or Semi-Metal that is ſo friendly to *Sulphur* as *Iron*.

145. *Regulus of Antimony* being well pulveriſed, mixed with *Sulphur*, melted, and ſtirred with a Hook, turns into *crude Antimony*, the Fuſion of which is likewiſe promoted by *Brimſtone*. However, it is more difficult than any of the foregoing to mix with *Brimſtone*.

146. The ſame happens to *Biſmuth* melted with *Brimſtone* over the Fire, as doth *Regulus of Antimony* (§ 145): Which however is a little ſlower. Thence a Maſs is produced, like *Antimony*, of a faint grey Colour, conſiſting of minute and very bright Needles [*Spiculi*] cutting each other acroſs, and extremely brittle.

147. *Zink* melted with *Brimſtone*, mixes with it not very eaſily; but if remaining long in a moderate Fire, it is covered over with *Sulphur* poured at ſeveral Times upon it, and continually ſtirred with a Poker, this at laſt produces a very brittle, dark-coloured, ſhining Subſtance.

Coroll. 1. Therefore, *Iron* being very greedy of *Sulphur*, all the other Metals and Semi-Metals may be freed of *Sulphur* by it.

Coroll. 2. A very ſmall Quantity of *Iron*, a greater Quantity of *Copper*, and a conſiderable deal of *Lead* and *Tin*, are neceſſary to abſorbe the ſame Quantity of *Sulphur*.

Coroll. 3. The reguline Part of *Antimony* is precipitated from *Sulphur*, by *Iron*, *Copper*, *Lead*, *Tin*, and *Silver*.

Coroll. 4. The *Scoriæ* ſwimming upon the *Regulus of Antimony* made by the abovesaid five Metals (*Coroll.* 3.) are more or leſs fuſible, according as theſe Metals melt more or leſs eaſily with *Sulphur* in the Fire: For the *Scoriæ of Regulus of Antimony* are nothing but *Sulphur of Antimony* mixed with precipitating Metals.

tals. Therefore, the Droſs of *Silver* is very eaſy, that of *Tin*, *Copper*, and *Iron* more difficult, and that of *Lead* the moſt difficult of all, to be melted.

148. If you throw into a Crucible red hot on the Fire, white *artificial Arſenick*, mixed with one tenth Part of *Brimſtone*, and cover it immediately with a *Tin*; and then pour it out after it has been one or two Minutes in Fuſion, it becomes a ſolid brittle Body, of a Citron Colour; but if you melt it in the ſame Manner with a fifth Part of *Brimſtone*, the Maſs, when grown cold, aſſumes the red Colour; if at laſt you melt or ſublimate *Arſenick* and *Sulphur* together, in an equal Quantity, it produces a fine red tranſparent Maſs, which is called *Rubinus Arſenicalis*, *Sulphur Auratum*, the Arſenical Ruby, Sulphur of Gold.

149. *Brimſtone*, melted with half the Quantity of fixed *Alcali* (§ 96). turns into *Hepar Sulphuris*, Liver of Sulphur, ſo called from its being of a Liver Colour; which, on account of the *alcaline Salt* it contains, makes all *Earths* and *Stones* melt ſoon in the Fire. When melted with any Metal whatever, it preſently makes it run, and renders it brittle, no longer like a Metal or Semi-Metal, and makes it diſſolvable by Water: This is ſo general, that even *Gold* and *Silver* are not excepted. Therefore, there are many Cautions to be uſed in the roaſting of *Oars* by different Fuſions.

150. A like *Hepar* (§ 149.) will be produced with vitriolate Tartar with *Sandiver* and other neutral fixed *Salts*, containing the vitriolick Acid, if, when they are red or in Fuſion in the Fire, you add to them Coal-duſt, or any other more fixt Phlogiſt.

151. The *Hepar Sulphuris* [a] is not ſo ſtrong, when made with fixed *Nitre* made with Coals, or with *Alcali* compoſed of *Tartar* and *Nitre*, nor with neutral *Salts* with an addition of *Sulphur*, already containing the vitriolick Acid.

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[a] Frid. Hoffmanni Obſerv. Phyſico Chemi.

Of CEMENTS.

152. We have already declared (§104, and 129.) what were the Effects upon Metals and Semi-Metals of acid *Menſtrua*, condenſed in a fluid Form, by a Heat not greater than that of the Fire which makes them ebulliate. It now remains, that we ſhould examine what are the Effects of the ſelf-ſame *Menſtrua* urged with the Degree of Fire which makes them red-hot, upon the Bodies aforeſaid.

153. But, as the acid *Salts* condenſed into Liquors (§ 105, 108, 113, 126, 128.) cannot bear to be made red hot, and are reſolved by a much leſs Fire, into Vapours which cannot be reſtrained; this requires another manual Operation: For the Acid of *Vinegar* cannot be extracted out of the Cryſtals of *Verdigreaſe*, nor the Spirits of *Nitre* and *Salts* be extracted out of them, by terreſtrial Additions, or by *Vitriol* (§ 113, 126); nor in ſhort the Acid of *Vitriol* itſelf be fetched out of its metallick or terreſtrial Matrix, without the Action of a very ſtrong Fire. Therefore, you are to proceed in ſuch a Manner, that the Bodies to be changed by theſe acid Spirits, be in the ſame Veſſel wherein the ſaid Spirits are produced, and, when made red hot therein, be ſurrounded on every Side with the agitated Vapours of the ſame Spirits. This is eaſily obtained, if you put the ſaid Bodies among the Matter itſelf which is to emit the acid Spirits, after having moiſtened it lightly, and preſſed it; and then expoſe them together to the Fire. This Operation is then called *Cementation*; and the dry *Species*, which melt the acid *Menſtrua*, and are commonly uſed for this Operation are called *Cements*.

154. The Proportion of the Additions uſed in making the *Cements*, is the ſame as in the Diſtillation of acid Spirits (§ 113, and 126). But *common Salt* and *Nitre* being the melting *Menſtrua* of Metals (§ 137; and *Vitriol* becoming extremely hard, by the

ſame Fire which is proper to be uſed in Cementations, that is, not a very ſtrong one; on this Account, they uſe a Quantity of *Brick-duſt*, *Colcothar*, &c. three or four times greater; leſt the *Salts* happening to melt, by employing a Fire a little ſtronger, they ſhould at the ſame Time put the Metals in Fuſion, and above all *Gold* and *Silver*: For this is the Method of preventing the melting of *Salts*; or if they melt, you at leaſt hinder them by that Means from running together, and from hardening to ſuch a Degree, as that the Maſs may not be pulled aſunder, and the interpoſed Metal be ſeparated, but with difficulty. For the ſame Reaſon, it is not proper here to uſe *Bole* alone, as an additional Help, becauſe it hardens like a *Stone* in the Fire.

155. But, that the Spirits which are driven out (§ 153, 154.) of the Matter of the *Cement*, may act the longer and with greater Force; the Veſſels, in which the Cementation is made, muſt be cloſed, the Cloſures being ſtopped with Clay, though not altogether without vent. By this Means the Spirits are beaten back, and yet not ſo abſolutely confined, as not to be able, when the Fire is increaſed, to make their way through the Cloſures of the Veſſels; which vent being not given them, the Veſſels would infallibly burſt.

156. Among Metals, *Copper*, *Iron*, *Lead*, *Tin*, and all Semi-Metals, being committed to any of the above-mentioned (§ 153, 154.) *Cements*, are totally corroded in a few Hours: Which will be the ſooner done, if they are intermixed with the *Cement*, in form of *Lamina's*, or of Granulation.

157. Thus it is that *Silver* is immmediately conſumed by the ſeveral Species of *Spirit of Nitre*: Nay, *Spirit of Salt* conſumes *Silver*, when uſed in this Manner, which otherwiſe does not corrode it, when it has the Form of a fluid Body. Nor does *Silver* reſiſt the Vapours of *Vitriol* in a Cementation. Nay, the *Vinegar* of Vegetables itſelf, concentrated in the Cryſtals of *Verdigreaſe*, and mixed with terreſtrial Bodies,

when uſed as a *Cement*, takes likewiſe ſomething from *Silver*. But *Gold* remains untouched, in all the aforeſaid *Cements*. The other Metals, and all the Semi-Metals, whenever they are intermixed with *Gold* (if this be granulated, or reduced into *Lamina's*) are eroded from it by Cementation; this however is ſomewhat more difficult for *Silver*; but *Copper*, when mixed with *Gold* in greater Quantity, is conſumed pretty ſoon: Nevertheleſs, a ſmall Part of it remaining in the *Gold*, is ſo ſtrongly defended by the latter, that it is a difficult Matter to ſeparate them perfectly by Cementation.

158. The ſeveral Compoſitions and Effects of *Cements*, ſhall be deſcribed in the following Part, when we come to the Operations to be made with *Gold*.

Of the SIMPLER *and* REDUCTIVE FLUXES.

159. Whatever cauſes a Body, hardly or not at all fuſible by Fire, to melt, is called a *Flux*.

160. But, what Species of Bodies have that (§ 159.) Faculty which cauſes them to be called *Fluxes*, you are to ſee (§ 46, and follow, 97, &c. 130, &c.) where we treated of the Glaſs of *Lead*, and of fixed and neutral alcaline *Salts*. Aſſayers uſe them, when they want to examine Minerals in a ſmall Quantity: This cauſes them to be called *Sales Fuſorii*. But when a greater Quantity of Minerals is to be worked upon, it is ſeldom poſſible to uſe *Fluxes* of this Kind with Benefit, becauſe they are very expenſive. Then, inſtead of the above-mentioned *Salts*, they uſe ſuch *Stones* as are vitrificable by a gentle Fire; or the *Scoriæ* made of the ſame *Stones* when melted, which ſerves this Purpoſe ſtill better: For the more often theſe *Stones* have been expoſed to the Fire, the more eaſily they are put in Fuſion: The Reaſon of which ſeems to be the alcaline *Salt*, proceeding from the Fewel of the Fire, and adherent to the ſaid *Scoriæ* (§ 97). Therefore, theſe Things being in large Quantities added to Ores, in great Operations, they

cauſe the ſaid Ores to melt, which are otherwiſe rendered refractory by the calcareous and incombuſtible *Stones* and *Earths* mixed with them: Which, however, is not ſo eaſily obtained with the ſaid *Scoriæ*, as by Means of the above-mentioned Glaſs of *Lead* and *Salt*. But the great Price of theſe hinders their being frequently uſed.

161. We have already ſaid (§ 51, 98, 133, and 137.) how uſeful theſe *Salts* (§ 159, 160.) were, for the melting of *Gold* and *Silver*, and of their *Calxs*. But when, in the Fuſion itſelf, *Gold* and *Silver* are to be purged of other Metals and Semi-Metals, then it is proper to uſe *Nitre* only, or at moſt *Nitre* together with other *Salts*. For Semi-Metals, and the four leſs perfect Metals, are deſtroyed (§ 137.) by *Nitre*; in which Caſe *Nitre*, by its Detonation with their *Sulphurs*, is in part alkalized, and, by help of a gentle Fire, turns the *Calxs* proceeding from theſe Metals, into a vitrious and much attenuated *Scoria*.

Coroll. Thence the Reaſon is plain, why *Gold* and *Silver*, made brittle, are readily reſtored to their Malleability by *Nitre:* For Semi-Metals, and among Metals *Lead* and *Tin* moſt of all, communicate this Fault to *Gold* and *Silver:* But being changed by *Nitre* in the Manner aforeſaid (§ 161.) they are in a ſimple Fuſion again rejected by *Gold* and *Silver:* So that they can no longer mix with theſe Metals, unleſs ſome Reduction is made. However, there is no other Body that can, by mixing with *Silver* and *Gold*, render them brittle, unleſs crude *Charcoals*, happening to fall into the Veſſel wherein *Gold* and *Silver* are melted, ſhould impregnate it with ſomething arſenical; there being ſome *Arſenick* contained in *Coals* of this Kind, as is demonſtrated by *Stahl* and *Hoffman*.

162. The moſt imperfect Metals and the Semi-Metals melt more eaſily, by adding *Salts* (§ 159, 160.) to them, than they do of themſelves. However, they always loſe a great deal of their Subſtance by this means, which happens eſpecially with regard to *Copper* and *Iron*. To mend this, it is neceſſary to

add ſome kind of fat Body, that prevents the Deſtruction, and reduces Metals already deſtroyed: And this is the more neceſſary, when *Calxs* prepared either by burning, or by a Detonation with *Nitre*, are to be reduced. The *Flux* proper for this Operation is very well prepared in the Manner following: Take one Part of *common Nitre*; of *crude Tartar*, thoroughly dried, two or three Parts; pound them ſeparately into a very fine Powder; then grind them well together; put them into an Earthen Pot, narrow at the Orifice, not glazed within, and of a Capacity three Times larger than the Powder requires: Which done, put them on a gentle Fire. So ſoon as the Maſs begins to be inflamed with a Noiſe, ſhut the Orifice with a *Tile*. After the Detonation, this will produce a black, oily, alkaline *Salt*, eaſily fuſible in the Fire, called *Fluxus Niger*, or *black Flux*; put it into a Pot cloſely ſhut, and in a dry warm Place, to prevent its growing moiſt.

Coroll. Tartar, being burnt alone in Veſſels cloſely ſhut, or detonated with *Nitre*, is moſt quickly alkalized, and thus retains a conſiderable Part of the *Oil* which it contains abundantly, and which is fixed enough. For this Reaſon, it very eaſily turns into a reducing *Flux*. This *Flux*, therefore, on account of its alkaline *Salts*, diſſolves *Earths* and *Stones*, and changes them into an imperfect kind of Glaſs (§ 97.) by a moderate melting Fire. But the *Oil*, being of a more fixed Nature, ſtill remains concealed therein, and is requiſite both to preſerve Metals from being deſtroyed, and to reduce ſuch as are deſtroyed already (§ 91).

Scholion I. *If the Pot is glazed within, and part of the glazing comes off, and mixes and melts with the* Flux, *it is again reduced to* Lead, *and thus may diſappoint the Artificer: Becauſe, this Cruſt of* Glaſs *is applied to Pots with* Litharge *or with* Lead.

Scholion. II. *All* Fluxes *muſt be kept and uſed very dry; for moiſt* Salts *foam very much; and when the Operations are done in cloſe Veſſels, if the Fire is quickly* *increaſed, not being able to get rid of the Moiſture, it ſplits the Veſſels.*

163. If equal Parts of the ſame Ingredients (§ 162.) are detonated in the ſame Manner, the *Oil* is almoſt entirely conſumed by the abundance of *Nitre*, and the reſt looks like an aſh or white colour'd *Salt*, more alkaline and ſharp than the foregoing; wherefore it is called *Fluxus albus*, or white *Flux*.

164. The *Fluxus albus* (§ 163.) is very efficacious to diſſolve *Stones* and *Earths*; but of a leſs reducive Virtue; and deſtroys the Metal, when the Fire is continued a little longer than is required.

165. Theſe *Fluxes* are likewiſe of very great Service, to reduce Metals from their reſpective *Calxs*, and to free them from the *Stones*, in which they are inherent. But when the refractory *Calx* of *Iron* is to be reduced by a great and long laſting Fire; theſe *Fluxes* being infinitely attenuated, though confined in cloſe Veſſels, 1. part from their oily Principle: 2. then their alkaline *Salt* remaining ſtill, they begin to conſume the Veſſels, of what Matter ſoever they may be made (§ 97), and ſlip away, making their way through them. The firſt Fault is mended, by adding *Coal-duſt*, becauſe this loſes not its fixed *Oil*, without the Help of a free Air: The other Fault is remedied with *common Glaſs* made of a due Mixture of *Flints* and fixed *Alkali*: For this is fuſible enough, it melts with *Fluxes* added to it, and by its Viſcoſity in a Manner coagulates and ſaturates the *Salt*, and thus hinders it from eaſily corroding the Veſſels.

166. Artificers compoſe a great many *Fluxes* with the above-mentioned *Salts* (§ 97, 130.) and with the reductive ones; nay, ſome uſe as many different *Fluxes* as there are different Ores and Metals; all which, however, we thing altogether needleſs to deſcribe. It is better to have explained a few of the ſimpler ones, which ſerve for all the others, and are very eaſily prepared, than to tire the Reader with confuſed Compoſitions: And this chiefly, becauſe unſkilled Artificers ſometimes attempt to obtain

with many Ingredients of the ſame Nature heaped up beyond Meaſure, and with much Labour, though not more properly and more ſecurely, what might have been eaſily effected, with one only and the ſame Ingredient, thus increaſing the Number, not at all the Virtue of the Things employed. Nevertheleſs, if any one loves Variety, he may, according to the Proportions and Cautions above preſcribed, at his Will chuſe among the ſimpler Kinds ſuch as will beſt ſuit his Purpoſe, and compoſe a Variety of *Fluxes* with them.

CHAP. III.

Of Docimaſtical Utenſils.

167. I Comprehend under this Title the Veſſels, Furnaces, and other paſſive Inſtruments, neceſſary for the conveniently and accurately perfecting of docimaſtical Operations.

I. *Of* VESSELS.

168. The firſt among docimaſtick Veſſels, is the *Coppel*, or leſſer Teſt made of *Bone-aſhes*, which is a Veſſel made of ſuch Matter, that it indeed contains melted Metals, ſo long as they are in their true metallick State, but abſorbs them, as well as all the other Bodies, when they are vitrified.

169. The Matter of *Coppels* (§ 168.) therefore, muſt be choſen ſuch as can reſiſt the ſtrongeſt Fire, not running eaſily into *Glaſs* with vitrificable Bodies, as for Inſtance with *Glaſs* of *Lead*, and fit to be reduced into a well-coherent, though porous Maſs. The beſt *Earth* for this purpoſe was found, that which is made of calcined Bones of all Animals, a very few excepted, eſpecially Swine-bones: For when it is made of the latter it receives ſomething metallick in it, at the ſame Time that it abſorbs

Glaſs. But the beſt Bones are thoſe of Calves, Oxen, Sheep and Horſes, eſpecially the ſmalleſt, which are the more eaſily calcined, the longer they have been expoſed to the Injuries of the Air.

170. The Calcination of theſe Bones (§ 169.) muſt be made for a few Hours, or more, according to their Bigneſs, in a great open Fire: Therefore, you muſt pick up the ſmaller ones, and thoſe which are leſs covered with fat. You will have a ſure Sign of the Calcination's being perfect, if you ſee not one black Spot without the Bones, nor any within when you break them.

171. When theſe Bones are perfectly white (§ 170), pound them in a Mortar, ſift them through a very fine Sieve; or, if you have none of this Kind at hand, grind the coarſer Powder upon a very hard *Stone* into a very fine Flour, and then waſh it with warm freſh Water: For during the Calcination, the Bones are almoſt always impregnated with the *Salt* of the Aſhes of the Fewel of the Fire. Then this will be an excellent *Earth* for the making of Coppels *.

172. Fiſh-bones, when very ſmall, are more eaſily calcined than thoſe of other Animals: Which may be eaſily done in a large open Earthen Veſſel. Theſe Bones being then pulverized are ſtill better than the foregoing (§ 171).

173. Parget or Plaſter made of ſome kinds of Spaad, is almoſt preferable to the aforeſaid *Earths* (§ 171, 172). But it is not every Spaad will ſerve this Purpoſe. You muſt then, before you prepare a Quantity of this Parget, previouſly try whether it will ſucceed, or not. The Calcination of this Kind of Spaad is made in an earthen Veſſel, cloſed with a Tile upon a gentle Fire: This occaſions a little crackling, which being over, the Calcination is perfect.

174. But, as the Preparation of the Aſhes of Bones is toilſome enough (§ 171, 172); and the ſaid Kinds of Spaad not to be found every where; on this Ac-

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* It is called by ſome *Clar*.

count, when you have a great many Coppels to make, you may ſupply this Want with Aſhes of Vegetables. But leſt the Coppels ſhould vitrify, becauſe of the alkaline *Salt* adhering to theſe Aſhes, you muſt previouſly uſe the following Preparation. Let hot, white, and very light Embers made of ſoft Wood, be ſtrained through a Sieve by pouring pure Water upon them; that all the Coals that happen to adhere to them, may be ſeparated, and the beſt and fineſt Aſhes may not fly away. Pour upon this ſtrained Duſt pure and boiling Water; ſtir it with a Wooden Stick; then let the Aſhes ſubſide quietly, and the Water which ſwims at Top, and which at firſt remains always troubled, be decanted: Pour new Water on the remaining Aſhes, and after they have ſubſided a ſecond Time, decant it again: Repeat this over and over, till the Water ſwimming at Top proves altogether inſipid: Then pour freſh Water again, ſtir it with the Wooden Stick, and after eight or twelve Seconds, pour it out, as yet troubled, into a clean Veſſel: Part of the Aſhes will remain in the foregoing Veſſel, in which the ſaid waſhing has been made: Pour Water upon this Remainder, ſtir it and waſh it likewiſe, and then, after a ſhort Reſt, pour it into the ſecond Veſſel: Repeat this in the ſame Manner, till there remains at the Bottom of the firſt Veſſel nothing but a little *Sand*, or ſome other coarſer Corpuſcules. Let the waſhed Aſhes reſt till they ſubſide, and the Water ſwimming at Top be decanted ſoftly. Thus you will have good *Earth*, free from redundant *Salt* and *Oil*, and immutable by Fire; which, however, being reduced into ſmall Balls, burnt again in a Potter's Oven, and then waſhed anew, will prove better ſtill.

175. Finally, put a ſmall Quantity of Aſhes of the Bones of Beaſts or of Fiſhes (§ 171, 172.) into a very clean Earthen Veſſel, and a ſecond Time calcine them during a few Hours, in the ſtrongeſt Fire, waſh them next with Water, then grind them upon a Porphyry into a moſt ſubtil Powder, to be kept ſe-

paratcly,

parately, for the Uſes ſoon to be mentioned. It is called in *German* **Claer.**

176. The hollow of the Coppels, which receives and contains the Metal, muſt be a ſpherical Segment, not very deep; firſt, that the Surface of the melted Maſs, let this be ever ſo much diminiſhed, be ſufficiently viſible to the Eye of the Artificer; ſecondly, that the Metal in that Cavity may melt together in one Globule. But the outſides of the Coppels muſt be only a ſmall Matter convergent towards the Baſis, like a truncated Cone; that it may ſtand firm upon its Baſis.

177. But that this Figure (§ 176.) may eaſily be given the Coppels, you are to have *Copper* or *Braſs* Moulds, the Figure of which is deſcribed (*Plat.* I. *Fig.* I. and II.) where we have added an exact Explanation. You likewiſe find their various Sizes, according to the Quantity of the Metal to be worked in the Coppels.

178. With all theſe Preparations (§ 168—177.) you will make the docimaſtical Coppels. 1. Take Aſhes of Bones, of Beaſts, or of Fiſhes alone, or two Parts of Wood Aſhes (§ 174.) and one Part of dry Aſhes of Bones (§ 171.) mix them well in a Mortar, or upon Porphyry; then add to them by Drops juſt as much Water, or of white of Eggs diluted with Water, as will be neceſſary to make the Matter ſtick together, when ſtrongly preſſed between the Fingers, and not more or leſs: Or if you uſe Spaad (§ 173.) let it be ſprinkled in the ſame Manner with a Solution of *Vitriol*. Put a large Quantity of the wetted Duſt into a ſmall Mortar (*Plat.* I. *Fig.* II.) ſupported upon a firm Prop; preſs down with your Fingers the Maſs poured looſely in; that the Capacity of the Mortar may be quite full of it; and lay the Remainder aſide. 2. Put the Peſtle perpendicular (*Plat.* I. *Fig.* I.) into the Mortar, and then with a Mallet drive it with three or four Blows, according to the different Diameter of the Veſſel that is to be made, and make

the Maſs pretty compact, taking care leſt the Peſtle ſhould rub againſt the Sides of the Mortar. 3. Having then removed the Peſtle, ſtrew the upper Part of the Cavity of the ſmall Veſſel, with Aſhes of dry Bones ground extremely fine (§ 175), which is done with the Sieve (*Plat.* I. *Fig.* IV): Again, put the Peſtle into the Mortar, after having firſt wiped it with a clean Rag, and drive it pretty ſtrongly with one or two Blows more. 4. Then have at hand a ſmall wooden Plank, ſtrewed a Quarter of an Inch thick with dry Aſhes, put upon it the Mortar containing the Coppel already prepared, ſo that the leſſer Baſis of it be underneath; preſs it againſt the ſmall Board: the Coppel will then eaſily quit its Mould: Let next the prominent Inequalities at the upper Edge and Bottom of the Coppel, be cut off with a ſharp Knife: Finally, let the Coppel inverted be laid aſide in a dry Place.

179. Therefore, the dry Aſhes called *Clær*, muſt be applied to the Inſide of the Coppel, that the little Inequalities moſt commonly remaining there, may be filled, and make a Sort of very fine Sieve, admitting through it vitrified Bodies, aud retaining *Gold* and *Silver*: Thus, when the Cavity of the Coppel is carefully done over with theſe Aſhes, it will be no great Harm, if the Maſs (§ 178.) uſed for the making of Coppels, happens to be defiled with a ſmall Mixture of *Sand* or of any other Powder more eaſy to be vitrified. And indeed it is hardly poſſible to avoid this Fault entirely, eſpecially when you uſe Wood-Aſhes. Thence the Reaſon is plain, why this Duſt (§ 175.) muſt be prepared with ſo much Care. Therefore great Cautions are to be taken, that the Levigation of this Duſt be not made upon a ſoft *Stone*: becauſe Particles of it being by Chance rubbed off might ſpoil the Powder.

180. The Coppels ought to be rather more than leſs compact: the latter being always hurtful; whereas the former, by abſorbing the *Glaſs* more ſlowly, does but retard the Operation a little.

181. Therefore, Coppels made of Aſhes of Bones of Beaſts, of Fiſh-bones, and of Spaad, are excellent, as they need not be made very hot at firſt, and require not the Regimen of the Fire to be ſo ſtrictly obſerved. But if you add to them Wood-aſhes, it will be neceſſary to make the Coppels pretty hot, before you put the Metal into them: Which being neglected, the aqueous Vapours, forcing their Way out, will cauſe the Metal to be thrown out in Drops; for Coppels of this Kind can never be perfectly dried by the Air alone; there being always ſomething of an Alcaline Salt adherent to Wood-aſhes, which attracts the Water out of the Air: As the dark Colour of theſe Aſhes, and the Solution of Ammoniack Salt poured upon them evidently ſhew. For which very reaſon, theſe Aſhes are more diſpoſed to Vitrification, than Aſhes of Bones; for the latter are nearer the nature of incombuſtible Stones.

Coroll. Hence likewiſe it is plain, why the dry Powder (§ 175.) wherewith the Cavity of the Coppel is done over, ſeparates more eaſily in the Operation of the Coppelling, when Wood-aſhes have entered into the Matter of the Coppels: Which is vaſtly prejudicial; becauſe, when theſe things adhere, they either increaſe the Weight, or cannot be got out of the Bed of Metal, without ſomething of it being loſt.

182. As to the moiſtening of the Matter of Coppels (§ 178.) you are to take care, (1.) Not to uſe a Fluid too mucilaginous and fat: For this makes Coppels ſo compact, that they not only reject vitrified Bodies, and yield them a very ſlow Paſſage, but alſo ſplit when made very hot, loſing firſt their oily Part. (2.) Not to uſe ſuch mucilaginous Fluids, as may produce a great deal of fixt Alkaline *Salt* in the heating of the Coppel; as the tartareous Dregs of fermented Bodies do. (3.) Not to moiſten the Aſhes too much: for then the Surface of the Coppels is never perfectly neat. (4.) Some mix about one tenth Part of decanted Clay to the ſaid (§ 178.)

Aſhes; And when this is done, the Matter muſt be moiſtened with Water only; becauſe the Clay makes the Aſhes ſtick ſufficiently together. However, take care that too much of Clay be not added; And you muſt always regard the ſeveral Degrees of Fatneſs of this *Earth*. (5) If the Aſhes of Bones are not ground too coarſe, their being ſprinkled with pure Water, makes them ſo coherent, that there is no need of adding any Clay, or mucilaginous Fluid, to increaſe the Coheſion; for Coppels of this kind, as well as thoſe made with Spaad (§ 173.) need hardly be made hot before the Metal is put into them.

Coroll. It is then plain, why the Operation done in a Coppel made with Aſhes of the Bones of Beaſts, of Fiſh Bones, or with Parget of Spaad, laſts a little longer, but is more ſecurely performed, than if Wood-Aſhes had been mixt to it. For as it receives more ſlowly a vitrified Metal, on account of its own compact Subſtance; ſo it is leſs to be feared, that any thing of a perfect Metal ſhould be abſorbed; though the Management of the Fire be not ſo ſcrupulouſly minded.

183. Theſe ſmall Veſſels made of Aſhes (§ 168.) ſerve for docimaſtick Operations not very extenſive: But if a larger Quantity of Metals is to be work'd upon, we accordingly uſe greater Coppels, one Foot and a half broad, commonly called *Teſt*. But theſe are made with Wood-aſhes; but not prepared with ſo much Care as (§ 174.) They add to them Brick-duſt beaten very fine. In this caſe, they uſe for Moulds, either the earthen Pot, or the Iron-ring repreſented (*Plat.* I. *Fig.* VIII. and XI.)

184. The manner of making them is as follows: (1) In an earthen Veſſel not glazed within, and by its Depth and Largeneſs proportioned to the different Quantity of Metal to be put in it. Let the inſide of it be well moiſtened with Water; that the Aſhes to be put into it may adhere the better. (2) Put the Aſhes juſt mentioned, and moiſtened in the

ſame Manner (§ 178.) as was ſaid about Coppels, into this Veſſel; ſo that it may be half full of them: Then preſs them with a wooden indented Peſtle, (*Plat.* I. *Fig.* XII.) or (if you are making but a ſmall Teſt) with only a wooden Cylinder an inch thick. When preſſed, add upon them ſome other Aſhes, to be preſſed in the ſame manner; till the earthen Veſſel be almoſt quite full: Remove the ſuperfluous Aſhes with an Iron Rule. (5.) Let the Inequalities remaining at the Border be ſmoothed with a wooden-Ball rolled about: This done, cut the Cavity with a bowed Iron (*Plat.* I. *Fig.* IX.) that you may have a broad ſpherical Segment, not very deep. (4.) With a Sieve, ſtrew this Cavity with dry Aſhes of Bones of Animals, ground extremely fine (§ 175.) and to be ſqueezed hard by the rotation of the wooden-Ball. Thus you will have a Teſt, which, together with its earthen Pot, muſt be put in a dry warm Place.

Another Manner.

185. Let an iron-Ring (*Plat.* I. *Fig.* VIII.) be filled with Aſhes like thoſe already mentioned (§ 183.) in ſuch manner, that they may riſe conſiderably above the ſaid Ring; then preſs them ſtrongly with your Hands, or with an indented Peſtle (*Plat.* I. *Fig.* XII.) (2.) Then, with gentle Blows of a Hammer, preſs the Aſhes from the Circumference towards the Center in a ſpiral Line, and in ſuch manner that, after having been ſufficiently preſſed, they may be a ſmall matter higher than the Brink of the Ring: Or, if there are Vacancies, empty the Ring, and fill it again with more Aſhes: For if you add ever ſo little of Aſhes, the ſecond put in do not cohere ſo ſtrongly with the firſt, but they may ſeparate in the Operation. (3.) This done, turn the Ring upſide down, and on the other ſide cut the Aſhes out with a Knife, to the Quantity of one third part of the Depth of the Ring, and again fill the Vacuity with the ſame Aſhes (§ 185. N° 1, 2), in ſuch a Manner,

a Manner, that there may remain no ſenſible Cavity. 4. Finally, cut out a Cavity in the larger Surface of the Ring, and in the ſame Manner mentioned (§ 184.)

186. The Teſts, called in German **Treibſcherben**, are Veſſels reſiſting the ſtrongeſt Fire, and ſo vaſtly compact, that ſometimes they not only retain melted Metals, but alſo the very *Glaſs* of *Lead* itſelf.

187. Their Figure and Size may be the ſame as that of the Coppels: However they commonly are made larger. To form them, they uſe a wooden or braſs-Mould, repreſented (*Plat.* I. *Fig.* V. and VI.) Nor is there any Difference between a Coppel and a Teſt, except that the Matter of the latter muſt be more compact and coherent.

188. The Matter fit for the making of Teſts is prepared thus: (1.) Make into Balls, Clay of the beſt kind, and pure; and dry them in the Air, or in the Fire: When dried, pound them in a Mortar: Pour upon this Earth abundance of warm Water; let this Mixture reſt a while; and when the Clay has ſubſided, pour out the Water which ſwims at top. The ſame Waſhing may be repeated, that all the minute Lumps of the Clay may be well ſoaked with Water, and any thing of *Salt* contained in them be waſhed off. (2.) Then add of the pureſt Sand, of Powder of calcined Flints ground, and well waſhed, of faulty but clean *Heſſian* Crucibles, or of any incombuſtible *Stones* ground very fine, ſuch Quantity as will render the Maſs thick, hardly adhering to the Hand of him that kneeds it, and hardly pliant when reduced into a ſmall Lamina. This Maſs will be fit for the making of Teſts.

189. But, before you make a great Quantity of Teſts with this *Earth* (§ 188.) it will be proper firſt to put into a ſingle one made with it, a Quantity of *Glaſs of Lead*, and to expoſe it for an Hour or more to the ſtrongeſt Fire. Thus you will be ſure,

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* Tobacco-pipe Clay, p. ii. Brick-duſt, p. i. Sturbridge Clay alone, or Sturbridge Clay, p. ii. Windſor Loam, p. i. will make very good Teſts to roaſt Ores in.

whether it can reſiſt Fire, and the *Glaſs of Lead:* For you cannot determine the exact Proportion of the Ingredients on Account of the Variety of Clays. Nature now and then affords in ſome Places Clay ſo well tempered, that it is extremely proper for the making of Teſts, without any Preparation, or without a Mixture of another Matter: Sometimes it only wants to be waſhed: But moſt commonly it muſt be firſt prepared in the abovementioned (§ 188.) Manner.

190. If then the Maſs under Trial (§ 189.) turns into Glaſs: you muſt add to it ſome of the aforeſaid Duſts of Stones, eſpecially of incombuſtible Stones. However, take care not to add too much of pulverized Chalk; for if the Matter is tempered with that alone, the Teſts made with it, will indeed reſiſt Fire the more; but, being too porous by this means, they yield a Paſſage to Litharge; which being abſorbed, they ſoften to ſuch a Degree, that they fall aſunder of themſelves, or are totally cruſhed when you take hold of them with Tongs.

191. Teſts are made in Moulds (*Plat.* I. *Fig.* V. and VI.) after the following Manner. Rub a little Mortar and the Peſtle lightly with Bacon or Oil; then fill firſt the two thirds of it with prepared Clay (§ 188.) and then with your Thumb make a ſmall Pit in the middle of the Clay; put the Peſtle upon it, and preſs the Matter with Blows of a Hammer, the ſtronger the better; and finally take the Teſt out of the Ring, in the Manner mentioned (§ 178. N. 4.) as was ſaid of Coppels.

192. The clayy Matter here to be uſed, muſt be ſo ſtiff and dry, that it may break the Moment you bend it with your Hands: For if it is too ſoft, it will hardly be poſſible to have any intire Teſts, or at leaſt they are miſhapen. Nor yet muſt the Clay be over dry; otherwiſe it would be difficult to faſhion.

193 Teſts thus made (§ 191.) and dried in a dry and moderately warm Place, may ſerve immediately, without being previouſly made hot; unleſs *Salts* or *Litharge* are to be managed therein: For theſe

Things, being melted in Veſſels not baked before, ſoon perſpire through them.

194. The aſſaying Oven (*Fornix docimaſticus*) or as others call it *Tegula*, *Teſtudo*; in *German*, and Engliſh *Muffle*, is an arched Covering, reſiſting the ſtrongeſt Fire, which in the Operation preſerves the Coppels and Teſts (§ 178, 191.) from the falling of Aſhes and Coals into them, and at the ſame time of ſuch a Form, as is no hindrance to the Action of the Air and Fire, nor to the Inſpection of the Aſſayer.

Coroll. You may then make your Muffles of what Form you pleaſe, provided they have the ſaid (§ 194.) Conditions requiſite.

195. But thoſe which ſerve for Eſſays made in Coppels, are moſt commonly made ſemi-cylindrical; but like a hollow Hemiſphere, when greater Aſh-Veſſels (§ 184, 185.) are imployed.

196. the Muffle muſt have Holes in it; (1.) That the Aſſayer may eaſily look into it: For which Purpoſe the forepart of it muſt be quite open (*Plat.* II. *Fig.* I.) (2.) That the Air may the better act in Conjunction with the Fire, and be inceſſantly renewed: For there is hardly any Fumes produced without the Action of it; which however is of an abſolute Neceſſity in the Vitrification of *Lead:* For when the Air is once filled with a certain Quantity of Vapours, it hardly admits any more after that; for which Reaſon a conſtant Renewal of Air is neceſſary. (3.) Beſides, theſe Holes ſerve for the Regimen of the Fire: For the cold Air ruſhing through the large Hole before, cools the Bodies put in the Muffle; or if, after having put ſome Coals in it, you ſhut this Aperture in part, or even intirely with a Door added to it, the Fire increaſes to the higheſt Degree; which can hardly be done ſo quickly by the breathing Holes of the Furnace. (4.) That the arſenical Vapours of *Lead* and *Antimony*, which paſs through the Holes made in the Baſis of the Muffle, may not be offenſive to the Aſſayer ſtanding by it.

Coroll. Therefore, when you are to fix the Height, Length, and Depth of Muffles, you muſt conſider, how many Veſſels, and of what Size, are to be introduced at once into it, and that the whole Inſide of the Veſſels, both foremoſt and hindmoſt, may be within the Reach of the Aſſayer's Eye: To which laſt Point you muſt have a ſpecial regard. But moſt commonly they are of the requiſite Dimenſion, when four Inches high, ſix or eight Inches long, and four or ſix Inches broad. The Segments cut off at the Baſis for the leſſer Holes, muſt be ſo high as that at leaſt the ſmall Veſſels put under them, may not be tainted by Coals and Aſhes falling into them. For theſe hinder the Vitrification of *Lead*, and the Deſtruction of the other Metals and the Semi-metals, and reduce them entirely when already deſtroyed: But the *Scoriæ* ſpoiled by Aſhes, ſoften and retard the Operation.

197. You muſt have wooden Moulds, for the forming of theſe Muffles, (*Plat.* I. *Fig.* 13).

198. The Matter which they are made of, is the ſame as that of Teſts (§ 188); provided it be a little more moiſtened and pliant *.

199. To form your Muffles, gather in one Maſs a ſufficient Quantity of *Clay* prepared (§ 198.) and moiſtened, ſo as to be ſomewhat pliant; kneed it well with your Hands, put it upon a Plane of *Stone*, or any other that may be not much changed by the Moiſture; extend the Maſs evenly into a Cake a little longer than the Muffle to be made, ſo broad as to exceed a ſmall Matter the Border of the ſaid Muffle, and ſo thick as that two or more thin *Laminas*, about two geometrical Lines thick, may be cut off from it: Which is eaſily done, by rolling upon the Maſs of *Clay* a wooden Rolling-pin, ſtrewed firſt lightly with Aſhes or Chalk. 2. With a thin braſs

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* Note Windſor Loam alone, or Sturbridge Clay alone, will make very good Muffles: but the beſt are made of Sturbridge Clay, p. ii. and old Muffles, or melting Pots, made of Sturbridge Clay, which have been uſed in the fire, beat to fine powder, p. i. and mixt.

Wire well ſtretched out, cut off from the Cake (N° 1.) a thin Plate, with great Caution, leſt it ſhould break; take it away, and having firſt ſmeered it over with Bacon or Oil, clap it upon the convex Part of the Mould (*Plat.* I. *Fig.* XIII.) 3. Then in the ſame Manner ſhut the hinder-Part of the ſaid Mould, with a like *Lamina* made Semi-circular, ſo that the Border of this *Lamina* may be joined together with the hinder-Border of the *Lamina* upon the convex Part of (N° 2.) the Mould; which is effected with Water, without which the hinder-*Lamina* would not ſtick to the fore one. 4. By the ſame Method, you may, if you think it proper, annex the Bottom, to the inferior Edges of the above-mentioned two *Lamina's*. Otherwiſe, you may leave the Bottom moveable, making it of a ſmall *Lamina* cut off from the Cake: In which Caſe, however, it muſt by its Breadth exceed by half an Inch the Sides and hinder-Part of the Muffle (N° 2. and 3), that the latter may with the greater Security ſtand upon it as a Baſis. Then, with your Hand wet, rub the Muffle thus made all over; that the ſmall Chinks, perhaps not ſeen, may by this Means be cloſed up on every ſide, and the *Clay* cloſely joined to the Mould. 6. When the Muffle applied to the Mould has been for ſome Hours in the dry Air, and it is become hard, cut off from it ſome Pieces, in the Manner aforeſaid (§ 196. *Coroll.*) and (*Plat.* II. *Fig.* I. and II.) which done, take the Mould ſoftly away: For if the Muffle ſhould dry perfectly upon it, it would certainly crack. When afterwards the Muffle expoſed to the Air for ſome Days, is quite dried, it is at laſt baked in a Potter's Oven, or even in the aſſay-Oven hereafter to be deſcribed; in ſuch Manner, nevertheleſs, that in the latter Caſe, the Coals, being lighted above firſt, may communicate the Fire ſlowly down to thoſe underneath: Otherwiſe, indeed, the exceſſive Force of the Fire would certainly occaſion Cracks in the Muffle. For which Reaſon, it is much ſecurer, to bake it in the firſt Manner mentioned.

200. If you adapt to the Convex Mould (*Plat.* I. *Fig.* XIII.) another Concave one (*Plat.* I. *Fig.* XIV.) in the Manner deſcribed in the Explication of the Figure juſt cited, ſo that the *Clay* between them may be formed by a ſtrong Preſſure; this will make Muffles much more ſolid with leſs Trouble, leſs apt to crack, and more capable to reſiſt the Fire. Now this is done in the following Manner. Put *Clay* a little drier than the foregoing, or that kind of *Clay* which is improperly called *French Clay*[*], into the hollow Mould, rubbed firſt with Bacon[†], and with your Hands extend it on the Semi-cylindrical Cavity of the Mould, and againſt the Board at the hinder Part (*Plat.* I. *Fig.* XIV. *l m*) then put upon the extended *Clay* the Convex Mould, rendered ſmooth with Bacon; ſo that the Sides of it may be equally diſtant from the upper Border of the concave Mould: Then put upon it the upper Board (*Plat.* I. *Fig.* XIV. *n. o.*) with Screws belonging to it (*g*), and by means of them preſs it ſo, as that the Board put upon it may touch the Body of the concave Mould: Which done, preſs finally the Convex Mould as much as poſſible againſt the other, by means of the hinder Screws, (*Plat.* I. *Fig.* XIV. *i. k*); then looſe the Screws, and, after having taken away the hinder and upper Boards, take out the Convex Mould: Which is done by means of a Screw (*Plat.* I. *Fig.* XIV. *lit. p*) that ſerves as a Handle. Thus you will have a Muffle formed, which is eaſily taken out of the cylindrical Cavity, and from the Baſis of which Segments may immediately be cut off: Finally, dry it well, and bake it as the foregoing ones (§ 199).

201. When larger Aſh-Veſſels or *Teſts* (§ 183.) are to be covered, they uſe large ſpheroidal Muffles (*Plat.* II. *Fig.* III.) made of caſt *Iron*, or they make Muffles of the ſame Kind with *Clay*, and upon Moulds of the ſame Figure (*Plat.* II. *Fig.* IV). Then the Maſs of *Clay* is extended with wet Hands only from the Top

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[*] *Windſor* Loam is as good as any.

[†] *Black-Lead* powder'd is better.

of the ſpheroidal Mould towards the Borders; and thus a Muffle is made with no great Trouble.

202. You ſee the Figure of the *melting Pots* and *Crucibles* (*Plat.* II. *Fig.* V. and VI). Theſe Veſſels, when ſmall, are made with a Baſis a little wider; both that they may not be thrown down, upon what they are ſet on, by the Coals put upon them, and leſt they ſhould fall, when taken out of the Fire, and put upon a Pavement not exactly horizontal.

203. Theſe Veſſels (§ 202.) are formed in wooden or braſs Moulds divided into two Parts, from Top to Bottom, that they may be disjoined and put together again. For this Reaſon, they adapt a broad iron-Ring, to the outſide of the Mould, in ſuch a Manner, that the two Parts of the Mould may be joined cloſe together, by applying the Ring to them, and ſeparated, by taking it away: Which appears better from (*Plat.* II. *Fig.* VII. and IX.) than from the Deſcription. However, this concave Model procures you only the external Form of the Veſſel, but the inward Cavity is made with a Peſtle (*Plat.* II. *Fig.* VIII).

204. The Matter theſe Veſſels (§ 202.) are made of, may be the ſame as that of the Teſts and Muffles (§ 188 to 190). Obſerve only, that it is proper to make uſe of the like Veſſels, which have already ſuſtained a great Fire, and are very clean, reduced into Powder, to correct the Stiffneſs of the *Clay*.

205. To make Veſſels (§ 202), with this *Apparatus* (§ 203), put your hollow Mould within the Iron Ring (*Fig.* VII. and IX), and lay it upon a firm Support: Then fill the Cavity of the Mould, with a ſufficient Quantity of Matter (§ 204.) very ſtiff; which Quantity can hardly be determined, otherwiſe than by Experience: Then preſs it down with your Fingers, or with a wooden-Stick, leaving an hollow in the Middle; ſo that the Matter may riſe a little beyond the Sides of the hollow Mould: Finally, put into it the Peſtle (*Fig.* VIII.) rubbed over with Bacon, and drive it down with ſeveral ſtrong St okes

of a Mallet: Then take away the Peſtle gently; and if the Matter is hard enough, and the hollow Mould ſufficiently poliſhed, the Veſſels may be immediately taken out of the hollow Mould, by removing the Ring: But if the Matter is too ſtiff, or too moiſt, and the hollow Mould not ſufficiently ſmooth, take away the Peſtle and put the Mould in a dry warm Place; and by this Means, the Mould may be opened, and the ſmall Veſſel be taken out in a few Minutes. When theſe Veſſels (§ 204.) are ſufficiently dried, they muſt be baked in a Potter's Oven.

206. The larger Crucibles and melting Pots are made in the ſame Manner. Only inſtead of a Mallet we uſe a Preſs, to force the Peſtle into the concave Mould.

207. There are Cautions to be uſed in the making of theſe Veſſels. (1.) A ſufficient Quantity of Matter muſt be put all at once into the Mould: For if you add to the Matter once compreſſed a new Lump of the ſame, it does not cohere with the firſt: Which happens likewiſe, when a Quantity of ſmall ſolid, or at leaſt compact Maſſes are put into it, without having firſt been well united by handling. Hence come many Chinks, and Pores, in the drying and baking, which often cannot be diſcovered by the Eye, nor by the Sound when the Veſſels are ſtruck, and mean while yield a quick Paſſage through them to the *Salts*. (2.) If theſe Veſſels are not made with a large Bottom, the concave Mould muſt not be beſmeered with Bacon: Otherwiſe, when you take out the Peſtle, the Veſſel ſticking to it, commonnly comes out of the concave Mould along with it; nor can it afterwards be taken off from the Peſtle, unleſs you break it.

208. In Fuſions, it is often neceſſary to cover the Veſſels with *Tiles*: Wherefore I give a Picture of them (*Plat.* II. *Fig.* X). Theſe are made of the ſame Matter as the melting Pots and Crucibles*:

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* A Piece of common plain *Tile* may ſerve as well, if made to fit the Veſſel.

For your common Earthen-ware, which is generally glazed with Litharge, grows clammy in the ſtrongeſt Fire, and ſticks to the Veſſels; ſo that they are taken off with difficulty, or even melt entirely. It is then better to cut off Pieces like Tiles, with a Knife, from a Cake of Clay (§ 188.) extended upon a flat Table, of the Bigneſs requiſite, according to the different Diameters of the Veſſels to be cloſed. Then pare away the Borders of the inferior Surface of the Plate ſo cut off, which is to touch immediately the Veſſel to be cloſed, leaving a Shoulder all round, by means of which the Tile is faſtened in ſuch a Manner, that it is not eaſily removed by the Poker, or when freſh Coals are put on the Fire. Finally, you put in the Middle of the outſide a ſmall Bit of the ſame Clay; that it may be eaſily taken away or put on the Veſſel again with Tongs, by means of this Kind of Handle.

209. The ſmall ſeparatory Cucurbites or Matraſſes (*Plat.* II. *Fig.* XI.) muſt be made of very tranſparent Glaſs, and yet capable of reſiſting the moſt corroſive *Menſtrua*, leſt they ſhould be corroded. Nor muſt they be too thick, eſpecially at the Bottom; for, when they are very thick, they eaſily burſt in the Fire. Let them be eight or ten Inches high, with a very narrow Orifice, hardly half an Inch wide; leſt the Matter therein contained, being in a violent Ebullition, ſhould riſe over the Mouth of the Veſſel, or at leaſt Part of it be thrown out in ſmall Drops, like a thin Rain, to which there is always a little of the Metal adhering; that in ſhort a greater Repercuſſion of the Fumes may be made. The bottom has a ſufficient Capacity, when it contains one or two Ounces of *Aqua Fortis*. It is beſides proper, that their Orifice be turned backwards into a broad Margin or Lip, leſt the Solutions, when poured out, ſhould run down along the Sides of the Veſſel *.

210. To ſupport ſuch a ſmall Cucurbite, (§ 209.) we uſe a Trivet (*Plat.* II. *Fig.* XII.) ſo made, that

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* A clean *Florence* Wine Flaſk will ſerve upon occaſion

ſmall Cucurbites of this Kind, and ſome of a Size a little larger, may be put upon it with equal Security. Therefore, let the Feet of it be ſpread wide aſunder, that ſome lighted Coals may eaſily be put under or taken away, and all the Appearances of the Solution be carefully examined.

211. Next to this, we uſe a Copper Skellet or Glaſs Bowl (*Plat.* II. *Fig.* XIII.) furniſhed with an Handle and a Nib, for the waſhing clean of the *Calx* of *Silver* precipitated by *Copper* out of *Aqua Fortis*. It is the better when made of *Copper*, becauſe it then can expel whatever Quantity of *Silver* remains in the Solution after the Precipitation. For there remains almoſt always ſomething of it. The Diameter of this Veſſel muſt be ſix Inches or more, its Depth about four Inches.

212. You muſt furthermore have at hand a ſmall golden Diſh, one Inch broad, and half an Inch deep, (*Plat.* II. *Fig.* XIV.) which ſerves to heat the Gold in red hot, from which another Metal has been eroded in a docimaſtical Operation; that any remains of the *Menſtruum* ſtill adhering to it may be diſſipated. It muſt be made of the pureſt *Gold*: For in an Earthen Diſh, grown porous and brittle by the Separation, part of the *Gold* might be ſcraped off: And, if it were made of another Metal, it would either melt, not being able to reſiſt ſo great a Fire, or caſt ſcaly *Scorias*, or even be corroded by the *Menſtruum* remaining in the *Gold*; and thus would both ways diminiſh the weight of the *Gold*, and deceive the Aſſayer.

213. You muſt likewiſe have a particular Iron Trivet (*Plat.* II. *Fig.* XV.) adapted to this Diſh (§ 212), to ſupport it.

214. The waſhing Trough or Tray (*Situla lavatoria*, *Plat.* II. *Fig.* XVI.) is an oblong Veſſel, in which the lighter and unprofitable Parts of the Ores are waſhed off, by pouring Water upon them and ſtirring it. It muſt be made of *Earth* or of *Stone*, not glazed, though of a clean ſmooth Surface. However,

ever, any other Veſſel of a middling Capacity, and pretty wide, may ſerve for the ſame Uſe.

215. Finally, you muſt have, for the Granulation of *Lead* and *Tin* above deſcribed (§ 44.) a granulating wooden Box, with its Cover, and ſo large as that ſome Pounds of Metal may be contained and well ſhaken in it. You have the Figure of it (*Plat.* II. *Fig.* XVII).

216. But to granulate Metals the wet Way, you may uſe any Veſſel, if it be but wide, filled with cold Water, which muſt be ſtirred about with a Broom. For Inſtance, the Metal, when a good Quantity of it is to be reduced into Grains at once, is firſt melted; then with a very ſmall red hot Crucible, held with a Pair of Tongs, it is laded up out of the larger Veſſel wherein is the whole melted Maſs, and while another Man ſtirs the Water about with the Broom, which he then raiſes one half above the Water, you pour it all at once upon the ſaid Broom, that it may fall through it into the Water. But the Sprigs of the Broom muſt not be too cloſe, leſt the Metal, being ſtopped by ſo many Obſtacles, ſhould wax cold too ſoon; and, by being detained between their Interſtices, adhere to them, and not reach the Water. When all the Metal has been thus injected, and the Water decanted, you will find it divided into ſmall Particles.

217. Some uſe a particular Machine, made on purpoſe for this Work, and repreſented (*Plat* II. *Fig.* XVIII). They take a wooden Cylinder, ſix Inches long, and ten in Diameter, and adapt to it an Axis and Handle, like a Grindſtone. Then cut all round longitudinally ſix or eight Channels about three Inches deep. Then put the Cylinder thus prepared upon a Tub or wide Veſſel, like that deſcribed (§ 216); ſo that the Axis of it, being received by Semi-circular Cavities cut in the Border of the Veſſel, may be kept ſteddy, leſt it ſhould fly out of its Place in the Rotation. Then the Veſſel is filled with Water to ſuch an Height, as that one third Part of the Cylinder may be immerſed in the Water; then throw the

melted Metal, laded up after the Manner mentioned (§ 216.) upon the Cylinder juſt deſcribed, which muſt be turned all the while upon its Axis with the Handle. By this Means, your Metal, made thinner than after the foregoing Manner (§ 216.) will be comminuted into thin Plates rolled together.

Scholion. *By both theſe Methods* (§ 216 and 217.) *combined, you may very well and with Security granulate* Gold, Silver, *and the ſeveral metallick Mixtures: But there is always ſome Riſk in the granulating of* Copper: *To avoid which, you muſt pour it only in a ſmall Quantity, and with a ſmall Stream: Which is more ſecurely done, if the Transfuſion is made through a red hot Crucible, having a few ſmall Holes at bottom; that the* Copper, *being as it were previouſly divided by this ſtraining, may thus fall upon the Broom* (§ 216.) *or upon the Cylinder* (§ 217).

218. The Cement-Pots are cylindrical Veſſels, made of Potter's Clay, with Tiles adapted to them, and turned by Potters. The Size of theſe Veſſels muſt be proportioned to the Quautity of Cement to be put (§ 153.) into them. However, it is not proper to make them above eight or ten Inches broad: For, when larger, the Fire acts with Difficulty and Inequality, eſpecially in the Middle of them.

219. You are to obſerve, that, in the making of theſe Earthen Veſſels (§ 218.) and of their Covers, all kinds of Clay contract and take up a leſſer Space in the drying and baking: Inſomuch however, that the purer Clay contracts one tenth Part of its Diameter: But the more it is mixt with Sand, or ſome other Duſt of Stones and Veſſels already baked, the leſs it diminiſhes; this Diminution being ſometimes hardly perceptible. Therefore, if a Veſſel, or a Cover of a determined Size, is to be made of Clay; it muſt be made greater than the required Bulk, in proportion to the Diminution, which Experience teaches you, Clay, either crude or prepared, undergoes in the drying up of it.

220. The melting-Cone (*Plat.* II. *Fig.* XIX.) ſerves for the Precipitation of melted Metals, which is made when two Bodies, melted together, and yet not mixing perfectly with one another in the Fuſion, ſeparate of their own Accord into two Strata, on account of their different ſpecifick Gravity. This Precipitation might indeed be made in the ſame Veſſel wherein the Fuſion is made: But, in this Caſe, you would be always under the Neceſſity of breaking the melting Pot every Time; becauſe the Part precipitated cannot be got out of it, when this Veſſel is intire. Therefore we uſe for this Work the above-mentioned kind of Cone, into which the melted Maſs is poured, and out of which it may be eaſily taken, when the Precipitation is perfect. But as the Quantity of the Matter to be precipitated is often but ſmall, the conical Figure has, on this account, been aſſigned to the melting-Cones, doubtleſs, that the heavy Matter, ſubſiding to the Point of it, may be collected into one ſolid *Regulus*.

221. The melting-Cone is made of Copper or of Braſs, that the Inſide of it may be ſufficiently poliſhed. When it is made of Braſs, you muſt take care that it be not made too hot: For then, when you ſtrike it with any force, it eaſily ſplits, on account of the Brittleneſs of this Metal in a great Fire.

222. When the Quantity of the melted Matter to be precipitated is conſiderable; you may uſe, inſtead of a melting Cone (§ 221), a large Braſs or Iron-Mortar, or any large Iron-Veſſel whatever.

223. Finally, when melted Metals or Semi-Metals are poured out, in order to be examined cloſely, or afterwards aſſayed in part; it is proper, in the pouring out, to give them an oblong Form not over-big: Becauſe they, by this Means, are more eaſily divided, and cut into ſmall Bits. In order to this, they uſe a Set of Moulds (*Plat.* II. *Fig.* XX.) called an Ingot, having one or many priſmatical or ſemi-cylindrical Furrows, of different Sizes, and well poliſhed, with a very

a very long Handle, and made of Iron, the propereſt Matter for this Inſtrument.

224. But when a ſmall Maſs of precipitated Metal is forthwith and entirely to be put into a Coppel; they chuſe to uſe a Mould, having the Form of a Segment of a little Sphere, and made likewiſe of Iron; ſuch as is commonly employed in pouring out ſuch Ores as have been extracted and ſcorificated by Lead. By this Means you are ſure to hinder the ſmall metallick Maſs, from ſcraping, with its angulous Surface, any Particle of the tender Bottom of the Coppel, while it is put into it, and, by this Means, from making it rough.

225. All theſe Moulds (§ 221, and 224.) muſt be well heated, before the Metal is poured into them; leſt they ſhould happen to be a little wet, or contract a Moiſture, eſpecially in cold Weather, by the ſudden Heat of the melted Maſs being poured into them: In which Caſe, the Matter poured in is oftentimes diſploded with very great Danger.

226. Moreover, they muſt be previouſly ſmeered over with Tallow, that the *Regulus's* may be more eaſily taken out of them, and that the Cavity of the Moulds may not be corroded, by the Maſs poured into them. But if a very great Quantity of Metal is to be poured out, eſpecially of a very ſulphureous Metal, or precipitated by means of Sulphur; the ſmeering of the Cone or of the Mortar with Tallow is hardly ſufficient, to prevent the Corroſion juſt mentioned: Becauſe the large Maſs of the Matter poured in remains hot for a conſiderable while. Therefore, in this Caſe they uſe a Lute, reduced to a thin Pap, with Water, which, being applied very thin to the Inſide of the Cone, or of the Mortar, is afterwards dried up. Thus, by means of this Cruſt, the Action of the Sulphur upon the Metal of the Cone is certainly prevented. Nay, pure *Copper* itſelf, though it be melted with no Sulphur, operates ſomething like this: Wherefore, it is neceſſary in this Caſe to uſe the ſaid Precaution.

227. Finally, Aſſaying requires that you ſhould have two Mortars; one of *Iron* and deep, to beat Bodies ſmall; the other leſs deep, of *Iron* or *Wood*, and wide; this muſt have a wooden Peſtle. The latter, moſt commonly of *Iron*, ſerves for Amalgamations: For Iron-Mortars are moſt fit for this Work; becauſe, though ſomething of the Iron be eroded by the Trituration, it nevertheleſs mixes not with the Amalgama: So that *Iron* is to be preferred to all other Metals, in Operations of this kind. Beſides, *Mercury* may be moderately heated therein, whereby the Amalgamation is very much accelerated: Which cannot be ſo eaſily effected in a Wooden-Mortar.

228. Beſides, for ſome Operations not directly belonging to the Art of Aſſaying, though it is proper that the Aſſayer ſhould be able to make them, by help of his own Skill, you muſt have diſtillatory Veſſels, ſuch as Earthen and Glaſs-Cucurbites and Retorts: But theſe being ſufficiently known, and deſcribed every where in chemical Books, I need not here be very particular in deſcribing them. I ſhall only obſerve, that the Glaſs-Veſſels, which are to ſuſtain a great Fire, are the better as they are thinner: For, when thick, they ſoon ſplit. But it is the contrary for the Recipient, which muſt be thicker.

229. When the Veſſels (§ 228.) are expoſed naked to the greateſt Fire; it eaſily happens, that they burſt, by throwing freſh cold Fuel into the Fire: For the preventing of which, you muſt have Recourſe to Lorication or Coating. This is performed in the following Manner: Take ſome of the ſame Matter, of which the Muffles and Crucibles are made (188), and, inſtead of Water, moiſten it with freſh Blood, not yet coagulated, and diluted with twice or thrice the ſame Quantity of Water, to make a thin Paſte of it: Then add to this Paſte Cow-hairs, or others not very long nor ſtiff: And, if you have at Hand Glaſs pulverized, and ſifted, it may alſo be of Service, to mix ſome of it with the reſt. Then with this Maſs

beſmear your Veſſel with a Pencil, and dry it: When dried, beſmear it a ſecond Time, and dry it again: Repeat this a third and fourth Time, till the Veſſel be covered over with a Cruſt or Coat, one third or fourth Part of an Inch thick.

Scholion. *To hinder the Blood from coagulating; you muſt, when it is juſt let out of the Animal, ſtir it with your Hand or with a Stick, till it is quite cold: Being thus attenuated, it will remain for ſome Days without coagulating.*

230. When you are to diſtil ſtrong corroſive Spirits, it is proper, for the ſhutting of the Veſſels (§ 228.) cloſe, to mix with the abovesaid Paſte, (229.) Bole, worked with Whites of Eggs diluted with Water, in a Quantity not to be determined otherwiſe than by Experience: This will give you a Lute, which will confine ſtrong Vapours.

II. *Of* FURNACES.

231. As the Practice of Aſſaying conſiſts chiefly in the refining of Foſſils by Fire; you are to have Inſtruments, in which the Fire may be contained, applied to the Subject, and augmented or diminiſhed to any Degree at your Pleaſure.

232. The firſt Furnace, peculiarly called the Aſſay-Oven (*Plat.* III. *Fig.* I.) is made in the following Manner. 1. Make with Iron Plates, a hollow quadrangular Priſm, eleven Inches broad, and nine Inches high, (a a, b b), ending at Top in a hollow quadrangular Pyramid (b b, c c) ſeven Inches high, terminating in an Aperture at Top ſeven Inches ſquare. But this Priſm muſt be cloſed at Bottom with ſuch another Iron Plate, which ſerves as a Baſis or Bottom to it (a a). 2. Near the Bottom make a Door (e) three Inches high, and five Inches broad, that leads to the Aſh-hole. 3. Above this Door, and at the Height of ſix Inches from the Baſis, make another Door (f), of the Figure of a Segment of a Circle, four Inches broad at its Baſis, and three In-

ches and a half high in the Middle. 4. Then faſten three Iron Plates on the fore-Part of this Furnace: Let the firſt of them (g g) eleven Inches long, and half an Inch high, be clipped, its lower Edge, againſt the Bottom of the Furnace, with three or four Rivets, in ſuch a Manner, that there may be between the upper Edge of the ſaid Plate and the Side of the Furnace, a Groove ſo wide, as that the Sliders of the lower Door (k k) may be put into it, and freely move backwards and forwards therein: Theſe muſt be made of a thicker iron-Plate. The ſecond iron-Plate (h h), eleven Inches long, three Inches high, and perfectly parallel to the foregoing Plate, muſt be clipt in the Space between the two Doors, in ſuch Manner, that both the upper and the lower Edge of it may form a hollow Groove with the Side of the Furnace. One of theſe Grooves, which looks downwards, ſerves to receive the upper Edges of the Sliders, that ſhut the lower Door (N° 2). The other, that looks upwards, is to receive the inferior Edges of the Sliders of the ſaid Door above (N° 3). The third Plate (i i) which is like the firſt, muſt be rivetted cloſe above the upper Door, in ſuch Manner, that it may form a Groove looking downwards, and contiguous to the upper Edge of the upper Door (N° 3.) 5. In order to ſhut both Doors (N° 2. and 3) you muſt adapt to each of them two Sliders made of Iron Plates, that may move within the above-mentioned Grooves (k k l l.) But the two Sliders belonging to the upper Door (N° 3.) muſt have each a Hole near the Top; that is, one a ſmall Hole $\frac{1}{3}$ Part of an Inch broad, and one Inch and a half long (m); and the other a Semi-circular Aperture, one Inch high and two Inches broad (n). Let beſides each der have a Handle, that they may be laid hold of, en they are to be moved. 6. Moreover, let five nd Holes, one Inch broad, be bored in the Furnace: vo of which muſt be made in the fore-Part of the urnace (o o), two others in the back Part, all at the eight or five Inches from the Bottom, but three

Inches and a half diſtant from each Side of the Furnace; and finally, a fifth Hole (p), at the Height of one Inch above the upper Edge of the upper Door (f). 7. In ſhort, let the Inſide of the Furnace be armed with iron-Hooks, jetting out half an Inch, and about three Inches diſtant from each other, to faſten the Lute with which the Furnace is to be covered over within. 8. Let then an iron, moveable, hollow, quadrangular Pyramid (q) three Inches high, be adapted to the upper Aperture (d) of the Furnace at the Baſis ſeven Inches broad, ending upwards in a hollow Tube (r) three Inches in Diameter, two Inches high, almoſt cylindrical, though ſomewhat convergent at Top. This prominent Tube ſerves to ſupport a Funnel or Flue, which is almoſt cylindrical, hollow, made of Iron Plates, and two Foot high (t), and which, when a very ſtrong Fire is required, is put perpendicularly upon the ſhorter Tube, in ſuch Manner, that it enters cloſe into it one Inch and a half or two Inches deep, and may again be taken off at Pleaſure, when there is no need of ſo ſtrong a Fire. But this pyramidal Cover (q) muſt beſides have two Handles (s s) adapted to it, that it may be laid hold of, and thus be taken away or put on again. And that this, being put on the Aperture (d) of the Furnace, may not be eaſily thrown down, let an Iron Plate be rivetted to the right and left upper Edge of the Furnace (c c), and be turned down towards the Inſide, ſo as to make a Furrow open before and behind, into which the lateral Edges of the Cover may enter and be faſtened, and at Pleaſure be moved backwards and forwards, whenever it muſt be put on, or removed. 9. Let a ſquare Ledge, made of a thick iron-Plate (*Fig.* II.) be faſtened at top of the upper Edge of the lower Door (e); this is deſigned to ſupport the Grate and the *Lute*. But it muſt be made of two Pieces, that it may be eaſily introduced into the Cavity of the Furnace. Thus you will have an Aſſay-Oven, which muſt afterwards be covered over inwardly on the Inſide with Lute: This you are to do as follows:

233. That the Fire may be the better confined, and the *Iron* not to be deſtroyed by growing red hot, the whole Inſide of the Furnace (§ 232.) muſt be covered over (See *Plat.* III. *Fig.* III. and IV.) with Lute, one Finger, or one Finger and a half thick. The Lute fit for this, is made with a Maſs of *Clay* (§ 188, 190), or with *French Clay*, moiſtened with three or four Times as much of Ox-Blood diluted with Water *. But before you cover the Inſides of your Furnace with this Lute, you muſt firſt put within the Furnace ſmall iron-Bars, equal in Length to the Diameter of the Oven, quadrangular, priſmatical, half an Inch thick, having their Extremities ſupported by the Ledge (§ 232. N° 2), and ¾ of an Inch diſtant from each other; and you muſt faſten them ſo, that their flat Sides may be oblique with regard to the tranſverſe Section of the Furnace, and that the two oppoſite Angles may look one upwards and the other downwards; the Bars muſt not be laid flat but edge-ways, by which Situation, you hinder the Aſhes of the Fuel of the Fire from being detained too long, between the Interſtices of the ſaid iron-Bars, and from making an Obſtruction, that would oppoſe the free Draught of the Air (See *Plat.* III. *Fig.* IV). The Furnace being then covered over with Lute, and dried up by a gentle Heat, is at laſt fit for docimaſtical Operations, and eſpecially for ſuch as muſt be performed in the Aſſay-oven (§ 194.)

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* The beſt Lute, and eaſieſt to be had at *London*, is a Sort of *Clay* called *Windſor*-Loam, which muſt be mixt pretty ſtiff, and preſſed into the Inſide of the Furnace, firſt wetted with Water, and, when the *Clay* begins to dry, it muſt be beat down cloſe to the Sides, with a wooden Mallet; then the Unevenneſſes and Cracks filled up with freſh *Clay* ſomewhat moiſter, ſo as to be made ſmooth and even with a Trowel, and then left to dry gently, and if any Cracks happen they muſt again be filled up. If any Pieces of this Lute are broken off by the Fire; let it be quite cold and wet, the Edges of the old Lute and freſh *Clay* will unite to it, and fill up the Holes; if the Crack is but ſmall, you may uſe the Furnace again immediately, even before the freſh *Clay* is dry.

234. If then an Operation is to be made in the Furnace hitherto deſcribed (§ 232, 233), you muſt let through the four lower Holes above deſcribed, of the Furnace (See *Plat.* III. *Fig.* I. o o) placed before and behind, and directly oppoſite to each other, two iron-Bars one Inch thick, and long enough that their Extremities on every Side may jut out of the Holes, a ſmall Matter. Theſe ſerve to ſupport the Muffle, and its Bottom (See *Plat.* III. *Fig.* III. and IV). You then introduce the Muffle through the upper Aperture of the Furnace (*Fig.* I. d.) and place them upon the above-deſcribed iron-Bars, in ſuch Manner that the open fore-ſide of it be contiguous to the inward Border of the upper Door f. (See *Fig.* III. and IV). The Fuel of the Fire is introduced through the Top of the Furnace (d); the Cover of which, on this Account, muſt be moveable, and not very heavy (q). The beſt Fuel for the Fire is Charcoal made of the hardeſt Wood, eſpecially of Beech, broken into ſmall Pieces of the Bigneſs of an Inch, wherewith the Muffle muſt be covered over ſome Inches high *. We then reject larger bits of Coals, becauſe they cannot fall through the narrow Interſtices, between the Sides of the Muffle and thoſe of the Furnace, and cannot of courſe ſufficiently ſurround the Circumference of the Muffle: Whence it happens, that there are on every Side Places void of Fuel, and the Fire is either not ſtrong enough, or unequal. But, if on the contrary, you uſe Coals too ſmall; then a great Part fall immediately through the Interſtices of the Grate into the Aſh-hole; and the tendereſt Particles of them turn too ſoon into *Aſhes*, and, by increaſing the Heap of *Aſhes*, obſtruct the free Draught of the Air, which is here greatly requiſite.

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* *Scotch Coal* or *Kennel-Coal* (but not *New-Caſtle* or *Sea-Coal*) broken into ſmall Pieces, may be mixed with an equal Quantity of *Charcoal*; or, if any Ores require long roaſting, the Fire may be firſt kindled with *Scotch Coal*; but the Operation is beſt finiſhed with tely *Charcoal*.

235. A perfect Management of the Fire is moſt commonly neceſſary, in the performing of Operations in this Furnace (§ 232, 233): Therefore, the Reader muſt give Attention to what follows. If the Door of the Aſh-hole (*Plat.* III. *Fig.* I. e) is quite open; and the Sliders of the upper Door (f) drawn towards each other, ſo as to touch one another in the Middle of the Door; and if, beſides, the Cover (q) and the Funnel (r) adapted to its Tube (r) is upon the Top (d) of the Furnace, the Fire will then be in the higheſt Degree poſſible: Though in the mean Time it is hardly ever neceſſary to put the Funnel on, except in a very cold Seaſon. But if, after having diſpoſed the Furnace in the Manner juſt deſcribed, you put red burning Coals into the open upper Door (f) of it, the Fire is ſtill more increaſed thereby: However, this Artifice is never, or very ſeldom, neceſſary. When you ſhut the upper Door, with only that Slider, that has a narrow oblong Hole in it (*Plat.* III. *Fig.* I. m) then the Heat becomes a little leſs: But it diminiſhes ſtill more, when you ſhut the Door with the other Slider, that has in it the Semi-circular Hole (n), which is larger than that of the firſt Slider: Nay, the Heat again is leſs, when you take away the Funnel put at Top of the Cover: Finally, the Door of the Aſh-hole being either in part or totally ſhut, the Heat is ſtill diminiſhed, becauſe the Draught of Air, ſo neceſſary to excite the Fire, is thereby hindered. But if, beſides all theſe, you likewiſe open the upper Door quite; then the cold Air, ruſhing into the Muffle, cools the Bodies put under it, that are to be changed, to a Degree never required in any Operation, and ſuch as will entirely hinder the boiling of *Lead.* If, during the Operation, the Fire begins to decay, or to grow unequal, it is a Sign that there are Places void of Coals, between the Sides of the Furnace and thoſe of the Muffle: Therefore, in this Caſe, you muſt ſtir your Coals on every Side, with an Iron Rod, which is to be introduced through the upper Hole (p) of

the Furnace; that they may fall together, and thus act in a proper Manner, and equally.

236. However, you are to obſerve, concerning the Regimen of the Fire juſt deſcribed (§ 235) that though the *Apparatus* is made with all the Exactneſs mentioned, nevertheleſs the Effect does not always anſwer it: The Cauſe of which Difference has moſt commonly its Origin in the various Diſpoſitions of the Air. For as every Fire is more excited by Coals in proportion, as the Air more condenſed, and more quickly agitated, ſtrikes them more violently (which the Effect of Bellows plainly ſhews) it thence appears, that in warm and wet Weathers, when the Atmoſphere is light, the Fire muſt be leſs efficacious in Furnaces; that likewiſe, when ſeveral Furnaces ſituated near each other, are burning at the ſame Time, the Fire is in part ſuffocated; becauſe the ambient Air is thereby rendered more rare and lighter. The ſame Effect is produced by the Sun, eſpecially in Summer-time, when it ſhines upon the Place where the Furnace is ſituated. The Atmoſphere, on the contrary, being heavier in cold dry Weather, excites a very great Fire.

237. The Heat of the Fire acts the ſtronger upon the Bodies to be changed, as the Muffle put in the Furnace is leſs; as the ſaid Muffle has more and larger Segments cut out of it; as the Sides of this Muffle are thinner; in ſhort, as there are more Veſſels placed in the hinder Part of the Muffle; and on the contrary.

238. In this Caſe, when many of the Conditions requiſite for the exciting of Fire are wanting, then indeed the Artificer, with all his Skill, will hardly be able to excite the Fire to a ſufficient Degree, in order to perform Operations well, in common Aſſay-ovens, even though he uſes Bellows, and puts Coals into the upper Door of the Furnace. For this Reaſon, I have put the Grate almoſt three Inches below the Muffle, leſt the Air ruſhing through the Aſh-hole, ſhould cool the Bottom of the Muffle which

happens in common Aſſay-ovens; and again, that the ſmaller Coals, almoſt already conſumed, and the Aſhes, may more eaſily fall through the Interſtices of the Grate, and the larger Coals ſtill fit to keep up the Fire, be retained. Finally, I have added the Funnel (*Plat.* III. *Fig.* I. *t.*) that the blowing of the Fire being, by means of it, increaſed as much as poſſible, this might at laſt be carried to the requiſite Degree: For the Fire may always be diminiſhed, but not always be increaſed at Pleaſure, without the Aſſiſtance of a proper *Apparatus.*

239. The other Furnace neceſſary to the Aſſayer is called a *melting Furnace*, and is likewiſe compacted of Iron Plates. The Cavity of it may be formed according to the elliptical Mould (*Plat.* III. *Fig.* V). 1st, Make an hollow Ellipſis, the Focus's 12 Inches aſunder, and the Ordinate 5 Inches long; cut it off in both its Focus's, that it may aſſume the Figure (*Plat.* III. *Fig.* VI). 2dly, Then make in this hollow Body, and near its lower Aperture, four Holes, eight Lines in Diameter, and directly oppoſite (*c c*). 3dly, Then faſten two flat iron-Rings (*d*), almoſt one Inch and a half broad, at both the upper and the lower inward Edge of this oval Cavity; and fill the Inſide of it with ſmall iron-Hooks, jutting out about ſix Lines, and three or four Inches diſtant from each other. Theſe, together with the Rings juſt mentioned, ſerve to faſten the Lute. Thus will the Body of the Furnace be made: Only you muſt add at the outſide two iron-Handles (*e e*), to be rivetted on each Side of it, that it may be taken hold of and moved. 4thly, Then make the Cover of the Furnace, which may be formed like the Part cut off from the Ellipſis (*Fig.* V. *a.* See *Fig.* VII). Let this have an opening (*b*) made in it, four Inches high, five Inches broad at bottom, and four Inches at the Top; and adapt to this an iron-Door hung on Hinges to ſhut it cloſe, and having at the Inſide a Border faſtened to it, anſwering exactly to the Circumference of the Door, and as prominent inwardly

as the Thickneſs of the Lute to be applied to it requires: (ſee *Fig.* VIII). For the ſame Purpoſe, let ſmall iron-Hooks be faſtened to the Inſide of this Door, which is intercepted by the ſaid Border. And leſt this Cover ſhould be burnt within, by the Force of Fire; you muſt cover the Inſide of it over with the ſame Lute mentioned before (§ 233.) for the Aſſay-oven: Therefore it muſt likewiſe be furniſhed with a Ring and iron-Hooks to faſten the Lute; as was ſaid before (N° 3.) when we ſpoke of the Body of this Furnace. Beſides this, you muſt faſten two iron-Handles (*Plat.* III. *Fig.* VII. *c c*) on the outſide of this Cover. Then a round Hole muſt be made in the Top of it, being three Inches in Diameter, prolongued into a hollow Tube (*d*) almoſt cylindrical, and a few Inches high, upon which the iron-Funnel deſcribed (§ 232. N° 8.) may, in Caſe of Neceſſity, be put after the Manner mentioned in the ſame Place when we ſpoke of the Aſſay-oven. 5thly, After this, the Lining of both the Body and Cover of the Furnace within is made in the ſame Manner above deſcribed (§ 233). Moreover, you muſt make for this Furnace two moveable Bottoms, *viz.* One to receive the Aſhes, and admit the Air; the other to ſerve for Reductions. The firſt is made with an Iron Plate, formed into a hollow Cylinder, open at Top, and to be ſhut at Bottom with an orbicular iron-Plate, as with a Baſis, five Inches high, and of ſuch a Diameter, as that it may receive the inferior Orifice of the Body of the Furnace (N° 2.) the Depth of half an Inch (See *Plat.* III. *Fig.* IX.) Therefore let an iron-Ring (*c*) half an Inch broad, be faſtened on the Inſide of the ſaid Bottom, and at the Diſtance of half an Inch from its upper Border, to ſupport the Body of the Furnace put into it. Again, let this Bottom have a ſquare Door, four Inches high, and as many Inches broad; that may be ſhut cloſely with a Door hung on Hinges, that you may by means of it increaſe or diminiſh the Draught of the Air, and thus govern the Fire at pleaſure. Then, on the left Side of this

Door, and at about half the Height of this bottom Part let a round Hole be made, one Inch and a half in Diameter, to admit the Pipe of the Bellows when Need requires. Next to this, let another bottom Part be made of the ſame Matter and Figure as the foregoing: Let it be likewiſe of the ſame Diameter, but two Inches higher, ſo that it may be of the Height of ſeven Inches. Likewiſe let it have round it a like iron-Ring below its upper Border, to ſupport the Body of the Furnace to be received in it. But let a Hole two or three Inches broad, and one Inch high (*Fig.* X. *c*), be cut out juſt below this Ring, in the Side of this bottom Part. Then let another round Hole be made in the left Side of this firſt Hole, fit to admit the Pipe of the Bellows (*d*). Further, let another round Hole like the foregoing (*e*) be made on the right, and at the Diſtance of one Inch from the Bottom. Then let the whole Inſide of this bottom Part (the Part above the Ring excepted) be overlaid with Lute, and a Bed be made at the Bottom, of a Figure like that repreſented by the Line (*f g b*). The Matter of which this is made, is common Lute pulverized, paſſed through a Sieve, and mix'd with ſuch a Quantity of Duſt of Charcoal, ſifted in the ſame Manner, as that the Mixture being moiſtened in the ſame Manner as the Aſhes (§ 178), and preſſed down, may at leaſt be lightly coherent. Of this Matter preſſed on the Bottom of the bottom-Part, a Bed is made, like a Segment of a Sphere, having in the Middle a ſmall Cavity ſomewhat lower, and made extremely ſmooth, after the Manner mentioned before (§ 184.) when we ſpoke of large Aſh-Veſſels or Teſts.

240. This Furnace (§ 239.) is chiefly fit for Fuſions, which may be made in it with and without Veſſels. When you are to melt with a Veſſel, put the Body of the Furnace (*Plat.* III. *Fig.* VI.) upon the firſt Bottom (*Fig.* IX.) that has a Door to it to open on Hinges; introduce two Iron Bars (*Fig.* XI.) through the Holes of the Furnace (*Fig.* VI. *c c*) put

upon them the iron-Grate (*Fig.* XII.) which you are to introduce through the upper Mouth of the Furnace: Then put in the Middle of this Grate a *Brick* or ſquare *Tile*, very ſmooth every where, warmed, and perfectly dry: Otherwiſe the Veſſels put upon it, eſpecially the large ones, are eaſily ſplit by the moiſt Vapours coming out of it in the Operation. Let the Height and Width of this *Stone* be a ſmall Matter broader and higher than the Bottom of the Crucible or Pot to be ſet upon it: For if it were leſs high, the Bottom of the Veſſel could not be ſufficiently warmed; and if it were leſs broad, the Veſſel might eaſily fall from it. Then put upon this *Tile* the Veſſel containing the Matter to be melted, and ſurround it immediately with Coals on every Side, which muſt be ranged according to the Method preſcribed before (§ 234). Then you govern the Fire, by opening and ſhutting the Door of the Aſh-hole (*Fig.* IX. *b*): You excite it by putting the Cover (*Fig.* VII.) upon the Body of the Furnace; and if beſides you put the Funnel (§ 232. N° 8) upon the cylindrical Mouth (*d*) of this Cover, the melting Fire becomes ſtill more violent. But if you moreover introduce the Bellows through the Hole of the bottom Part, (*Fig.* IX. *d*), and the joint of the Furnace with the bottom Part, and the Door of the Aſh-hole, unleſs it can be ſhut very cloſe, being exactly ſtopt with thin Lute [*or Windſor Loam*] the Fire thus excited by the blaſt of the Bellows is carried to the higheſt Degree, and far ſurpaſſes that which may be made in a Smith's Forge. Another Advantage of this Method is, that the Veſſels are not ſo eaſily broken, becauſe the blowing of the Bellows cannot affect them immediately, and becauſe a Fire perfectly equal is excited on every Side. One may eaſily examine with this *Apparatus*, how *Stones* are affected by the Violence of the Fire only. Now, if you have a mind to perform any Operation without a Veſſel, and with a naked Fire; for Inſtance, to melt and reduce the *Calxs* or *Scorias* of *Copper*, *Tin*, *Lead*, and *Iron*, or the Oars of theſe Metals; the Body of the Furnace muſt be put upon the other Pedeſtal, having a Bed in it (*Plat.* III. *Fig.* X). However, you muſt before this open with a Knife the oblong Hole (*c*), and the round one (*d*) of this bottom Part, which are ſtopped with the Lute ſticking to the Inſide. Then you apply at the round Hole (*d*) on the left the Bellows, in ſuch Manner that the Nozel of it being directed obliquely downwards, may blow ſtrongly againſt the Bed (*fg b*): By this Means, all the Aſhes that fall into the Bed are blown away, and the Strength of the Fire determined to ſuch a Degree, that all the melted Bodies that fall into the ſaid Bed, remain in their State of Fuſion: And were it otherwiſe, the melted Bodies would immediately wax cold, and adhere in Grains to the Bed, whereas they ought to have melted into one *Regulus*. The oblong Hole in the forepart of this bottom-Part (*c*) ſerves to diſcover by means of a Poker, whether the Matter in the Bed be melted, or not: It ſerves likewiſe to take away through it whatever might ſtop the Bellows, and in ſome Caſes to take away the *Scoriæ*. Then you put firſt Coals into the Furnace, one Span high, and blow them well with the Bellows, to make them burn, that the Bed may be very hot before the Matter to be melted is put into it: For if this is not previouſly done; the melted Maſs ſeldom runs into a *Regulus*, but remains diſperſed among the *Scorias* which ſoon grow hard. The Bed being well heated, and freſh Coals added to the Fire, put into it ſuch Quantity of the Matter to be melted as cannot hinder the Fire from being carried to the requiſite Degree: Which cannot be determined otherwiſe than by Experience: Again, put freſh Coals, and upon them another Quantity of the Matter to be melted; they may be like *Strata* one upon another. But if the Maſs once melted could not long ſuſtain the Strength of the Fire; or if you had a mind to melt a greater Quantity of Matter than what can be contained in the Bed; you muſt open the round lower Hole (*Plat.* III.

Fig. X. *e.*) that you may make a Channel paſſing from that Hole through the Lute, and reaching to the ſmall Cavity at the Bottom of the Bed (*g*): To this Hole at the outſide, apply an earthen Diſh like the Bed within, or any other proper Recipient, ſurrounded with burning Coals, into which the Matter melted running from the Bed through the Hole (*Fig.* X. *e*) may be collected (*Fig.* XIII. *i*). The other Particulars hereto belonging, and to be obſerved in ſpecial Caſes, will be more eaſily recited, when we come to the Operations hereafter to be explained in the practical Part of Aſſaying.

Scholion. *In determining the inward Figure of the Furnaces which are employed to carry the Fire to the higheſt Degree of Strength, you muſt not be ſo ſtrictly exact in giving it ſuch a Figure, as that the reflected Rays of the Fire may all be collected in one certain Point or Line. For the Matter wherewith the Furnaces are lined within, can never aſſume ſo ſmooth a Figure: Nay, if this Matter might aſſume it by any Art, it would ſoon be ſpoiled again by the Violence of the Fire. Beſides, the Rays of the Fire caſt by the Coals, do not fall with the ſame Regularity as thoſe of the Sun and of Sound; nor can they of courſe be ſo exactly reflected towards the Body to be changed, or the ſaid Matter itſelf being naked, is moſt commonly covered all over with Coals. On the other Hand, a* Focus *collected within ſo ſmall a Compaſs, would be of almoſt no Service; becauſe it can act only upon a very ſmall Part of the Body to be changed. It is then enough to give the Furnace ſuch a Figure and Size, as that it may* 1. *admit a ſufficient, though not ſuperfluous Quantity of Fuel for the Fire:* 2. *That it may confine the Heat of the Fire, ſo as that it may neither act with too much Liberty, nor be diſſipated before it has acted ſtrongly enough upon its Subject: For which Purpoſe ſome Sort of Cover muſt be added.*

241. The Furnaces hitherto (§ 231 to 240) deſcribed, are ſufficient for the performing of docimaſtical Operations ſtrictly ſo called. But the Aſſayer muſt alſo perform other Operations, ſubſervient to

the foregoing: Such are the Diſtillation of acid Spirits, Cementations, Calcinations, *&c.* which cannot be conveniently done in the Furnaces above deſcribed: Therefore, as theſe Operations moſt commonly want a long and conſtant Fire; it will be very proper, for this Purpoſe, to conſtruct a Furnace called an *Athanor*, which can contain as much freſh Fuel as will keep up the Fire for many Hours together, and admits of a different, an accurate, and moſt conſtant Regimen of the Fire.

242. Let then, 1st, a ſmall ſquare hollow Tower (*Plat.* IV. *Fig.* I. *a a a a*) be conſtructed of ſuch *Stones*, [or of Bricks made of *Windſor Loam*,] as may reſiſt the Fire; let the Sides of it be ſix Inches thick, and forming a ſquare Cavity within, of ten Inches on each Side (*b b b b*). The height of it is determined, according as it is to keep up the Fire long, without any Addition of new Fuel: Five or ſix Foot are moſt commonly ſufficient [*]. 2. At the bottom of this Tower make an Opening (*c*), ſix Inches broad and as many Inches high; hang to it an iron-Door, being on every Side one Inch broader than the Opening, and ſuch as may ſhut it very cloſe: For which Purpoſe the external Edge of this Opening muſt be excavated all round in ſuch Manner, that it may form a Groove one Inch broad, into which the Edges of the Door may be received. 3. At the diſtance of ten Inches from the Bottom of the Tower, put a Grate (*d*), made of priſmatical, quadrangular iron-Bars, one Inch thick, and three quarters of an Inch diſtant from each other: Let alſo each of theſe iron-Bars, be ſo ſituated with regard to the Tower, that the two oppoſite acute Edges of each may look perpendicularly, one downward, the other upwards, that, by this Means, the Aſhes may eaſily fall into

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[*] Theſe Towers may likewiſe be made of caſt Iron, in form of a truncated Cone, ſix Inches diameter in the Clear within at top, and twelve at bottom, made with a Groove round the Top for an hemiſpherical Cover to be put upon it; and the Bottom of the iron Tower muſt be ſet upon the Stone or Brick-work, juſt above the Opening at (*c*) deſcribed at N° 4.

the Aſh-hole. 4. Make above this Grate an Opening circular at Top (*e*), ſix Inches high, ſeven Inches broad, that may, as well as the Aſh-hole (N° 2), be opened and ſhut with an iron-Door. 5. Adapt to the Top of the Tower an iron Cover (*f*), exceeding the Aperture of the Tower all round two Inches, and having a Handle, wherewith it may be eaſily taken away, and put on again. Thus you are to make the Furnace called in *Latin Furnus primarius*. 6. Then cut out in any Side of the Tower, for Inſtance in the left, an oblong ſquare Aperture, going up obliquely toward the outſide (*gg*), four Inches and a half high, ten Inches broad, having its inward inferior Edge, one Inch and a half, or two Inches above the Grate (*d*), that, by the intervening of this Hole, the Cavity of this Tower may communicate with another immediately to be deſcribed. 7. Nearly over-againſt the ſame Side of the Tower, make a Cavity with Stones, whoſe inferior Part muſt be a hollow Priſm (*Plat.* IV. *Fig.* I. *b b b b*), ſix Inches high, twelve Inches broad, ending at Top in a Semi-cylindrical Arch (*i i*) deſcribed by a *Radius* of ſix Inches; that by this Means, the Height of the whole Cavity be twelve Inches in the Middle. Let this anterior Cavity be totally open, though, when requiſite, to be ſhut very cloſe with an iron-Plate (*k k k*), whoſe inward Surface is to be conſtructed, in the ſame Manner preſcribed (*Plat.* III. *Fig.* VIII.) for the ſliding Door of the melting Furnace, and then luted two Inches thick within. Moreover, let there be in the Middle of this Plate, a round Hole (*Plat.* IV. *Fig.* I. *l*), four or five Inches in Diameter, and let the Circumference of this Hole have an iron cylindrical Border made to it, and prominent within; that by means of it, the Lining of Lute within may be ſupported, and kept from falling down eaſily. Let a Notch one Inch broad, and two Inches deep, be made in the outward Circuit of the Aperture of this Cavity, to receive the Extremity of the Plate that ſhuts the Aperture. The Hole of this Plate (*l*) either is ſhut with a Stopple (*m*), or ſerves to paſs the Neck of the Retort through. This Plate likewiſe is faſtened with two Bolts (*n n*); to be put horizontally with the iron-Hooks (*o o o o*), driven into the Wall near the Edge of the Aperture, ſo that one Bolt may faſten the upper Part of the Plate, and the other the lower. 8. It is moreover proper, that the ſquare Aperture (*g g*), through which the Fire enters from the Tower into the Cavity hitherto deſcribed (N° 7.) may be ſhut and opened at Pleaſure with an iron-Slider: For if this is not done, an exceſſive Fire, employed ſometimes by an unexperienced Hand, cannot be ſo eaſily checked. For this Purpoſe, let a Slit half an Inch broad, and eleven Inches long, be left in the Wall that conſtitutes the upper Part of the Cavity (N° 7), and is contiguous to the Tower; ſo that it may exceed the Length of the ſquare Aperture (*g g*) a ſmall Matter on every Side, and reach before and behind into the ſmall Grove, going down along the perpendicular Sides of the ſaid Aperture (*g g*), and retain the iron Slider to be put into it to keep it ſteddy. However, let this iron-Slider (6) be ſix Lines thick, eleven Inches broad, and five Inches high; and let a Couple of ſmall iron-Chains (*p p*) be faſtened on each Side of its upper Edge, wherewith the Slider may be lifted up and let down again. Therefore, let a Couple of ſtrong iron-Nails ** be drove into the Contiguous Wall of the Tower, perpendicularly over thoſe Places, in which the ſaid ſmall Chains are faſtened to the iron-Slider, that any of the Links of the Chains may be ſuſpended on them at Pleaſure. Moreover, let the upper Edge of the Slit above deſcribed be entirely ſhut up with Stones and Cement, leaving only two ſmall Holes through which the ſmall Chains may be paſſed. 9. On the left of this (N° 7.) Cavity, and at the Diſtance of eight Inches from the Bottom of it, let a ſquare (*q q q q*) Chimney or Funnel be erected with *Bricks*, three Inches and a half in the clear, four Foot high, and a ſmall Matter convergent upwards, ſo that the Diameter of it at Top may be three Inches. This Funnel muſt be contrived to be ſhut cloſely with an iron-Slider, having a Handle to it *(r r)*, which Slider muſt move freely between a double iron ſquare Frame *(s s s s)* faſtened in the Walls of the Funnel, at ſuch a Height from the Hearth as ſhall ſeem convenient to any Artificer. 10. Blow this Chimney, let a ſquare Aperture be made, like the foregoing (N° 6 *(g g)*, leading obliquely up to the Bottom of another cylindrical Cavity *(u u u u)*, which is eight Inches deep, deſcribed by a *Radius* of ſix Inches, open at Top, and there converging inwardly into a Border one Inch thick, and ſix Lines broad, deſigned to ſupport an iron-Pot. Likewiſe, cut in the anterior Wall of this Cavity, and at the upper Part of its Mouth, a Segment two Inches and a half deep, five Inches broad, and ſtooping forward *(v v)*, to receive the Neck of a Retort. 11. To this Cavity (N° 10.) belongs an iron-Pot *(w w)*, eleven Inches broad, and about nine Inches deep, which muſt be incompaſſed with an iron-Ring *(x x)*, one Inch broad, and faſtened at the Diſtance of one Inch and a half from the upper Edge of the Pot. Let a Segment *(y)* be likewiſe cut off the upper Edge of this Pot, which Segment muſt be four Inches and a half deep, and five Inches broad: The iron-Ring juſt deſcribed muſt be bent all round the Edges of this Segment. 12. Over againſt the Aperture *(t t)* which communicates from the firſt Cavity (N° 7.) into the ſecond (N° 10.) let another ſuch Aperture *(z)* be made two Inches diſtant from the Bottom of the ſecond Cavity (N° 10.) perfectly like the foregoing *(g g t t)*, and communicating obliquely upwards with a third Cavity (1 1 1 1), like, and equal to the ſecond cylindrical Cavity *(u u u u)*; that the Fire may paſs from the latter into the former. 13. In the hinder Part of the Wall which makes the Aperture juſt menaioned *(z)*, let a Chimney like the foregoing *(q q q q)*, and of the ſame Height (2 2 2 2) be erected, that may be ſhut with a Slider like that (3). 14. Finally, on the left Side of the third Cavity (1 1 1 1) let an Aperture be made in the ſame Manner (4), and like the foregoing ones (*g g t t z*) more remote however from the Bottom of the Cavity, without a Paſſage at the other Extremity, and communicating only with the Cavity of the third Chimney (5 5 5), which muſt be erected in the ſame Manner as the two foregoing ones (*q q q q*. 2 2 2 2). Thus you will have a Furnace very proper for a great many Operations.

243. We are now to ſpeak of the uſe of the *Athanor* juſt deſcribed (§ 242); and chiefly to mention, to what Operations each of its Parts ſerve in particular, and then how the Fire may and muſt be governed in it. 1. You muſt put at the upper arched Door (*e*) of the Tower, a Semi-cylindrical Muffle twelve Inches long, which muſt be introduced through the Door: Which for this Reaſon muſt be of the ſame Height and Breadth as that Door, three Quarters of an Inch thick, and open behind, being ſhut there by the hinder Part of the Athanor, as far as which it muſt reach. For this Purpoſe, a *Tile* muſt be ſet upon the Grate (*d*) to ſupport the Muffel. Let alſo this Muffle have ſmall Pieces cut out near its Baſis, as common Aſſay-muffles (*Plat.* II. *Fig.* I. and II.) You may put under this Muffle your Cement Pots, or ſuch Bodies as muſt be calcined with a long violent Fire: Which can be done without a Muffle, though not ſo neatly. 2. In the firſt Chamber (*Plat.* IV. *Fig.* I. *h h h h i i*) you may make the moſt violent Diſtillations with an open Fire: For Retorts or large Veſſels are introduced into it, after you have taken away the Door (*k k k*), and are put either upon the Hearth itſelf of this Chamber, or upon a particular Support of Stone. But you muſt place theſe Veſſels in ſuch manner, that their Necks may eaſily paſs through the Hole (*l*) of the Door, when put on again: For which Purpoſe, they chuſe a Support ſometimes higher, ſometimes lower, according to the different Heights of the Veſſels. When afterwards the Door is put on again, and faſtened with both its Bolts (*n n*), you muſt cloſe with Lute all the Chinks which lie

open about the Neck of the Veſſel, and between the Edges of the Door and the Entrance of the Chamber. Then you apply to the Neck of the Veſſel a cylindrical Segment, ten or more Inches long: By means of which the Heat and the boiling Vapours coming forth are gradually diminiſhed; leſt the Recipient, which is always choſen a Glaſs Veſſel, ſhould ſplit. The Recipient, which muſt be united with the other Orifice of the ſaid Segment, is ſupported either by the Pavement, or by a certain kind of Trivet, the Conſtruction of which is ſuch, that it may be ſet lower or higher by means of three Screws. 3. In this ſame Chamber, inſtead of Diſtillations, you may alſo make Cementations, Calcinations, *&c.* In which Caſe the round Hole (*l*) of the iron-Plate may be ſhut and again opened with a Stopple (*m*), that one may view the Inſide. 4. The ſecond and third Cavities (*uuuu.* 1 1 1 1) ſerve chiefly to ſuch Operations as are made in Baths [or Beds] of *Sand*, *Aſhes*, or *Filings.* For Inſtance, you put into each of theſe Cavities a Pot (*w*) and you ſtop with thin *Lute* or with *Sand*, which muſt previouſly be moiſtened, the Slit between the iron-Ring (*xx*), and the Border of the Cavity, upon which this Ring reſts. 5. Beſides, you may alſo make in theſe two Cavities, Diſtillations by a reverberating Fire, as well as in the firſt: Only the Fire is leſs violent in theſe, though ſufficient to extract *Aqua Fortis.* You then take out the iron-Pot (*w*), and inverting it, you put it upon the Mouth of the Chamber; ſo that the Brim of the Pot, being the Depth of one Inch and a half above the iron-Ring (*xx*), wherewith this Pot is ſurrounded, may be received within the Mouth of the Cavity, and ſo that the Segment cut in the Pot (*y*) may, together with the Segment cut out from the Side of the Cavity (*v v*), form a Hole to let the Neck of the Veſſel through. 6. All the *Apparatus* being thus ready; you firſt introduce through the Top of the Tower (*b b b b*), a few burning Coals: And put upon them ſome of the unkindled Fuel of the Fire; that the Cavity of the Tower may, according as it is thought neceſſary, be filled either entirely or only in part. Then with all Speed you put upon it the iron-Cover (*f*), and ſtrew the Border of this on the outſide, with *Sand* or *Aſhes*, which you preſs gently with your Hands: For if you ſhould neglect this Point, all the Fuel contained in the Tower would be kindled, and may endanger ſetting the Houſe on Fire *.

244. We ſhall here annex a few general Rules concerning the Regimen of the Fire in this Furnace: For it is hardly neceſſary to explain all Particulars, ſince Practice will eaſily hint them to ſuch as ſhall be ever ſo little acquainted with Chemiſtry. The Fire may be made very ſtrong, in the firſt Chamber (*Plat.* IV. *Fig.* I. *b b b b i i*), when the Door of the Aſh-hole (*c*), and the Funnel (*qqqq*) of the Chamber is quite open, and when the iron-Slider ſuſpended with Chains (6. *p p*) does not hinder the Fire from paſſing freely from the Tower into this Cavity. But the cloſer the Funnel is ſhut, together with the Door of the Aſh-hole; the more the Violence of the Heat diminiſhes: And this will be ſoon effected, if the iron-Slider ſuſpended with Chains, is let down in part: For the Fuel contained in the Tower, burns at leaſt as high as the Space between the lower Edge of the iron-Slider and the Grate (*d*). Obſerve beſides, in thoſe Operations, wherein the round Hole (*l*) of the Door is ſtopt with a Plug (*m*), that when the ſtrongeſt Fire is required, this Hole muſt not be kept long open: Becauſe the Air ruſhing violently through it, ſoon cools the Bodies put into the Cavity. The Operation mentioned (§ 243.) may be performed in the ſecond and third Chamber, in, and at the ſame Time, and with the ſame Fire, as they are in the firſt Chamber: For the Fire penetrates from the firſt Cavity into the ſecond, and increaſes when the Funnel (*2 2 2 2*) erected on it is opened. But before you

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* Therefore the iron-Tower mentioned page 88. is more ſafe, becauſe the Groove at top may be filled with water, or Lute mixt very thin with water, which will effectually hinder any air or ſmoak from getting through.

do this, the Funnel of the firſt Cavity muſt be ſhut as much as that of the ſecond is opened. By the ſame Means, you may hinder the Fire, which ſerves for the Operations made in the two firſt Cavities, from going out through their Funnels, and you force it out, on the contrary, through the third Cavity and through its Funnel *(555)*; that it may alſo act upon the Bodies placed in that Cavity. For the more the Funnel erected upon the third Cavity is open, the more one or even both Funnels of the other two Cavities muſt be cloſed. Thence it is plain, that you cannot kindle the ſtrongeſt Fire in the third Cavity, unleſs there be one equally ſtrong in the other two; and that on the contrary, the Heat in the third Cavity may be rendered leſs, by cloſing its Funnel; though it be violent in the others. The ſame is true of the ſecond Cavity, with regard to the firſt. Finally, you cannot make the ſtrongeſt Fire under the Muffle placed within the upper Door *(e)* of the Tower, unleſs you have an equal Fire in the firſt Cavity, which Fire may conſequently be increaſed, by ſhutting the Door quite againſt the Muffle *(e)*, and diminiſhed by opening it; there being mean while an equal Heat in the firſt Chamber, and in the following ones. The reſt will eaſily be learned by Practice.

III. *Of the other Utenſils of* Aſſaying.

245. Aſſayers make uſe of four Sorts of Tongs. the firſt (*Plat.* IV. *Fig.* II.) conſiſts of two iron-Legs, two Foot long, as many Lines thick, joined together in the Middle with a Rivet *(a)*, ſo as that they may be ſhut and opened ſteddily. Let the fore Part of theſe Legs wherewith the Veſſels are laid hold of, be curved on the inſide *(b)* into a Semi-lunar Figure; and let the hinder Part have two Rings *(c)* to manage the Tongs with. This Tool ſerves to draw the Teſts and ſmaller Crucibles out of the Furnace.

246. The ſecond kind of Tongs are made of a Plate of *Steel*, hardened to a Spring-temper. Let them be ſix Inches long, almoſt ſharp in the fore Part,

and well poliſhed (*Fig.* III). With theſe you take up the metallick Grains remaining in the Coppels, and other minute Bodies.

247. The third kind of Tongs (*Plat.* IV. *Fig.* IV.) are adapted to melting Crucibles of a middle Size, three Foot long, having very ſtrong Legs, and as to the reſt made like the firſt (§ 245); except that each of the Legs muſt be bent downwards at their Extremities, into a ſort of Beak, ſome Inches long, and one Inch and a half broad; that the Sides of the Crucible being ſqueezed faſt between theſe, it may be held ſteddily. Theſe Tongs are chiefly uſed, when Metals melted in Veſſels of a middle Size, are to be poured out into Moulds or Ingots.

248. The largeſt Veſſels, containing a great Quantity of Metal, are more eaſily cracked in the Fire than the ſmall ones; and their Cracks, if they do not proceed from the Moiſtneſs of the *Tile* ſet under them, are always found in the higher and larger Part of the Veſſel, and moſt commonly run from the Top towards the Bottom, ſeldom tranſverſely. To be able to take ſuch Veſſels ſafely out of the Fire; you muſt have Tongs ſtronger and longer (*Fig.* V.) than the foregoing (§ 247). Let one of their Legs be curved a ſmall Matter at the End, and end in a ſtrong Semi-circle eight Inches in Diameter, and ſo fixed, as that it may make half right Angles with the Leg of the Tongs (*a*): Let the other Leg be curved in the ſame Manner at the End, and have at its Extremity two Semi-circles like the foregoing, but ſo ſituated among themſelves, and with regard to the foregoing, that they may be diſtant from each other about one Inch, ſo that there may be a Space in which the Semi-circle of the other Leg may be received (*b*): The Effect of this Structure is, that ſmall and large Veſſels may be managed with them. The Veſſel to be taken out, is laid hold of a little below its upper Border, with the curved Extremity of theſe Tongs, which muſt be firſt heated juſt red hot in the Fire; and being thus ſurrounded with a whole Circle, is ſafely taken out of the Fire.

249. When the Matter put into ſmall Veſſels is to be ſtirred; you muſt make uſe of an Iron-Hook, two Foot long, and one Line and a half thick (*Plat.* IV. *Fig.* VI). It is proper to have two or three of theſe Hooks; that is, as many as there are Veſſels together under the Muffle, with the Matter to be ſtirred; that you may not be obliged to uſe the ſame Hook to ſtir them all, and that the Matter in one Veſſel may not be ſpoiled by Particles of that of another, which may happen to ſtick to the Hook: For you have not always Time enough to beat off with a Hammer, or to file off the adhering Particles.

250. When Aſhes muſt be removed from the Convexity of the Muffle; or when Vacuities and Interſtices happen to be between the burning Coals, that render the Fire unequal; you ſometimes introduce into the Hole of the Aſſay-oven (*Plat.* III. *Fig.* I. *p*) an Iron-Rod (*Fig.* VII), wherewith you throw the Aſhes down, and make the burning Coals fall together.

251. The Matter in the Crucible is to be ſtirred with the Iron-Hook (*Fig.* VIII.)

252. When Operations are to be made in the larger kind of Teſts, it is proper to have a ſtirring Iron (*Fig.* IX.) four Foot long, with which you either ſtir the Maſs, or take out the more clammy *Scoria's.*

253. When the Grates are ſtopped, you clear them with the Hook (*Fig.* X.) the Size of which is ſelf-evident.

254. The ſmall Iron-Ladle (*Fig.* XI.) ſix Lines in diameter, well poliſhed, and having a Handle two Foot long, ſerves to put Bodies, which muſt be previouſly broken ſmall, into the Veſſels, eſpecially ſuch Veſſels as are under the Muffle. You muſt have a larger hollow Ladle, whoſe Figure is ſufficiently known, to melt *Lead*, *Tin*, *&c.* in a gentle Fire.

255. A ſtrong Fire, if you look at it too long, not only dims your Eyes, but alſo hinders you from obſerving diſtinctly the ſeveral Changes of the Bodies. To remove this Inconveniency, you muſt provide a ſmall Board, made of the drieſt Wood, and one Foot

both in Length and Breadth; that it may ſcreen your whole Face. It has a Handle one Foot and a half long: And a Slit is cut in the Middle of it horizontally, one Line and a half broad, divergent towards the other Side of the Board, to be turned againſt the Fire, and ſufficiently extended each way; that there may be a larger Field for Viſion, and both Eyes may at once eaſily diſtinguiſh the Objects. We will call this Inſtrument a *Screen*, through the Slit of which the Workman may ſee, without any Apprehenſion from the Fire, or from the Sparkles that fly, and thus ſafely contemplate his Object. (*Plat.* IV. *Fig.* XII.)

256. To kindle the Fire, you muſt, beſides the ſmall Hand-Bellows, have a larger *double Pair of Bellows*, three Foot long (*Plat.* V. *Fig.* I), ſuch as are uſed by Goldſmiths and Farriers. Let them be ſupported by a wooden-Frame, ſo well fitted, as that they may at Pleaſure be raiſed up, and let down before and behind, about the Height of one Foot. The Structure of this Inſtrument is ſufficiently known, from the above-mentioned Figure. If theſe Bellows lie by unuſed, they muſt be kept ſtretched, and every Quarter of a Year rubbed with Neat's-foot or Train Oil: for, this being neglected, the Leather cracks ſoon, and the Ligaments grow ſtiff; which occaſions a weak and unequal Blaſt.

257. Some, inſtead of Bellows, uſe an *Eolipyle*, which is a hollow Ball, made of a Plate of Copper, and about ſixteen Inches in Diameter, having an open Pipe coming out of it, in the Direction of a Tangent, and nearly ſuch as is put on a large Pair of Bellows. If you ſet this Veſſel two thirds full of Water, on the Fire, ſo that the Water within may boil ſtrongly; and then direct the Aperture of this Tube towards the Fire to be blown; a Blaſt ruſhes out of it, and blows the Fire with great Force. However, you muſt forbear uſing this Inſtrument, when Copper is melted without a Veſſel, and is collected in the Bed of the Furnace (§ 240): the

more, becauſe it is not uncommon to ſee large Drops of Water ſpouting out of the Tube of the *Eolipyle*[*].

258. When ſmall Pieces of Metal are to be melted; the beſt Way to do it, is to put them upon a hard Piece of Charcoal, with a ſmall Hollow made in it; and then direct the Flame of a Lamp having a large Cotton, upon the ſmall Maſs of Metal to be melted, by blowing it thereon with a ſmall crooked Pipe: For by this Means, *Iron* itſelf may be melted without any *Apparatus*: Which ſucceeds ſtill better, by adding *Borax*. Let the Pipe, with which this is performed, be made of Copper, and let it have in its bending Part, a hollow Globe one Inch in Diameter, through which the Wind is to paſs, that the Moiſture of the Breath gathering into ſmall Drops may be collected within the Cavity of this Globe, and not reach the ſmall Flame, and hinder the Action of the Fire. Let the leſs Aperture of this Tube through which the Wind comes out, be ſo ſmall, as to admit hardly the ſmalleſt Needle. This is called the *cementing Tube*, or *Blow-pipe*.

259. The *Load-Stone* is often ſufficient to diſcover Iron: For want of this Stone, you muſt have Recourſe, for that Purpoſe, to a long and tedious *Apparatus*. Therefore, the Aſſayer ought to be provided of one well armed, and keep it loaded in a dry Place.

260. You muſt likewiſe be provided of an *Anvil*, the upper Surface of which muſt be perfectly well poliſhed, and about one Inch ſquare, with a ſmall Hammer adapted to it: Both theſe muſt always be kept perfectly clean, leſt they ſhould be ſpoiled by Ruſt and Dirt, and contract Furrows: Otherwiſe, if the Metal is vitiated, or any thing goes from it, it hinders many Operations, eſpecially that Separation of *Gold* from *Silver*, which is called *Quartation*, and ſhall be explained in our practical Part.

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[*] A very cheap and ingenious kind of Bellows have been newly invented by Mr. *Triewald*, Captain of Mechanicks, *&c.* to the King of *Sweden*, a particular Deſcription of which is to be ſeen in *Philoſ. Tranſ.* Nº 448, to which I refer the Reader.

261. However, he that purſues the Art of Aſſaying, can never be without an Anvil, large Hammers, a Vice, Files, Wedges, *&c.* but theſe, being ſo well known, want no Deſcription.

262. It remains, that we ſhould examine and give an Exact Deſcription of the *Aſſay Balance*, and the Manner of correcting the Defects of it; becauſe it is an Inſtrument of the utmoſt Importance in docimaſtical Operations, and ſerves to determine exactly the Weights of minute Bodies.

263. Let this Balance be made of the beſt Steel: For it may be conſtructed much better of this Metal, which muſt be of the hardeſt Kind, though ſufficiently tractable, than of any other Matter. Beſides, Steel is not ſo eaſily ſpoiled with Ruſt, as Iron; and it is more apt than other Metals to take a perfect Poliſh, which at the ſame Time prevents the Ruſt. Meanwhile, let the Steel to be employed for this, be tempered a little ſofter than a perfect Spring; that it may return to its State, when ſlightly bent; for it cannot then eaſily contract Faults, and if it does, they may be eaſily mended.

264. The Structure of the Aſſayer's Scales is hardly different from that of common Scales, otherwiſe than by its Nicety and Smallneſs. The longer the Beam of it (*Plat.* V. *Fig.* II.) is, the more ſmall Faults will be ſenſible in it: Therefore, the longer muſt be preferred to the ſhorter. However, ten or twelve Inches are a ſufficient Length. Let the Thickneſs of it be ſo very ſmall, that two Drachms may hardly be hung at either of its Extremies (*a b*), without its bending. For the largeſt Weight put upon it ſeldom exceeds one Drachm. The whole Surface of this Beam muſt be altogether without Ornaments, which do but increaſe the Weight, and gather Filthineſs. The Beam is ſuſpended in a Fork (*Fig.* III.) the two Legs of which are ſteel-Springs joined at Top, but kept together below with a braſs, pliant Claſp (*Fig.* IV) parallel, and two Lines and a half diſtant from each other. This Claſp being taken off, and

the Legs of the Fork being ſtretched out, the Axis of the Beam may be put into two Holes (*a a*) made for that Purpoſe at the Ends of the Legs, or be taken away from them. Let a very ſharp Needle (*c*) be fixed in the Head of the Fork, ſtanding perpendicularly downwards, if the Fork is ſuſpended, and ſo long, as that it may almoſt touch the Top of the Tongue of the Beam (*Plat.* V. *Fig.* II. *c*) put into the Fork, when in *Equilibrio*. This Needle is the Mark of the *Equilibrium*; and that the Artiſt, who ſtands over-againſt it, may be able to obſerve this, the Legs of the Fork muſt be broader in that Place, and have an Opening two or three Lines (*d*) wide. However, this Fork may be adorned at Pleaſure; provided the Motion of the Balance is not hindered by ſuch Ornaments. Then take two Scales made of a thin Plate of *Silver*, almoſt flat, one Inch and a half in Diameter, hanging on three ſmall ſilk-Strings, almoſt as long as the Beam, tied together at Top with a *Silver* Hook, in form of an S, and hang them to the Extremities of the Beam. A ſmaller * ſilver Diſh, ſomewhat leſs than one Inch in Diameter, belongs to each of theſe Scales (*Fig.* V.) You firſt put into theſe Diſhes, with a Pair of Pincers, the Bodies to be weighed, or with a Spoon or a ſmall Shovel, when they are pounded, and then you put them into the Scales: Therefore the ſmall Diſhes muſt be perfectly equal in Weight. We uſe them, that Bodies may be more conveniently put into and taken out of the Scales, and that theſe, which are vaſtly thin, may not be bent, ſoiled, and ſo be rendered falſe by wiping.

265. This Balance (§ 264.) is ſuſpended on a moveable Braſs or Copper-Support, which conſiſts of a Pedeſtal (*Fig.* VI. *a*), and of a Column ſet upon it (*b*) about twenty Inches high, at the Top of which comes out a right Angles an Arm (*c*) one Inch long. At the Extremity of this Arm, put a ſmall Pully (*f*)

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* Or if made of Steel blued over Charcoal they are leſs apt to wear.

three Lines in Diameter: Put another at the Top of the Column (*e*), and a third near the Bottom of it (*d*): All which Pullies muſt turn very eaſily on their Axis. At the Diſtance of one Inch and a half below the upper Arm, let another Arm one Inch and a half long (*g*) come out of the Column at right Angles, having a Hole through it (*h*) two Lines long, a quarter of a Line broad, and placed perpendicularly below the Pully ot the upper Arm (*f*), to receive a ſmall Plate (*i*), one Inch and a half long; and of ſuch Breadth and Thickneſs, as that it may freely move up and down, and yet not have too much play within the Hole. Moreover, let this Plate have a ſmall Hook at each Extremity.

266. And as ſuch a Balance is very tickliſh, and will hardly ſtand ſtill in the open Air, and becomes falſe, when ſpoiled with Duſt: It muſt be put, together with its Support, into a ſmall Caſe, having Glaſſes at Top and all round it, that you may ſee what is within. The Size of ſuch a ſmall Caſe is evident; and muſt be ſuch, as that the Balance ſuſpended on its Support, may be conveniently placed and turned in it. The Windows of the right, left, and fore Sides of it, muſt be made in ſuch Manner, that they may be opened and ſhut without any great ſhaking of the Caſe. The Baſis of it muſt be a Draw, two Inches high, equal in Breadth to the Caſe, jutting out in the fore Part four or five Inches beyond the Front of it, and eaſy to be drawn out and thruſt in again. In this Draw you muſt put the Weights, incloſed in their little Partitions, a ſmall Pair of Pincers, a ſmall Shovel, or a Spoon, wherewith to put the Powders into the ſmall Diſhes of the Scales, and other Things, if any are requiſite: By which Means, you will have all theſe Inſtruments at hand, and keep them perfectly clean (See (*Plat.* V. *Fig.* VII.)

267. The *Apparatus* we have hitherto deſcribed (§ 263—266, is diſpoſed for uſe in the following Manner. Paſs a Silk String over the three Pullies of the Support (*Fig.* VI. *e f d*), and tie it at its upper Extre-

mity to the ſmall Hook of the Plate (*i*), which is then introduced into the Hole of the inferior Arm (*b*). Then you put the Support (§ 265.) in the Middle of the ſmall Caſe (§ 266), and you paſs the other Extremity of the ſilk-String below, through a Hole bored in the Middle of the lower Border of the Frame, containing the Window in the fore Part of the Caſe, and faſten it to a Weight of a few Ounces (*K*), reduced into a cubick Form. Next to this, you muſt ſuſpend the Fork of the Balance (*Fig.* III.) on the inferior Hook of the Plate (*i*) *Fig.* VI). By this means, if you move backwards and forwards the Weight faſtened to the String (*K*), placed upon the Top of the Draw, that juts out beyond the fore Part of the Caſe, the Balance within is either lifted up, or let down. But you muſt put the Bodies to be weighed, and the Weights themſelves in the ſmall ſilver-Diſhes (*Fig.* V), and you put theſe, when loaded, into the Scales, through the ſide-Windows, which muſt be opened for that Purpoſe. When any thing is to be added to, or taken out of them, you do it with the ſmall Pincers, or, if it is Powder, with the ſmall Shovel or Spoon. However, you muſt let the Balance down, every Time any thing is to be added, or taken away; that the Scales may reſt upon the Bottom of the Caſe: But then you muſt ſhut the Windows, before the Balance is lifted up again, eſpecially if the Air is not perfectly calm (*Plat.* V. *Fig.* VII.)

268. To ſee whether the Balance (§ 264.) is juſt, or no, you muſt interchange the ſmall Diſhes. That is, you firſt put the ſaid Diſhes into the Scales, and lift up the Balance, to ſee whether it is in *Equilibrio*, or not: If not, you will procure the *Equilibrium*, by adding granulated Lead to the lighteſt Diſh. This *Equilibrium* once obtained, you put the Diſhes in the Place of one another, and again lift up the Balance: If it keeps ſtill in Equipoiſe, it is a Sign of its being juſt: But if, after the Permutation of the Diſhes, you no longer find the Balance in *Equilibrio*; it is a ſure Sign of its being faulty. Moreover when, the Ba-

lance being elevated, you ſee the Beam moving in the Fork, not only up and down, but alſo ſide-ways, this likewiſe ſhews a Defect in the Balance. You muſt beſides reckon it one of the Faults of your Balance; if, when having lifted it up, and put it in *Equilibrio*, you lower one of the Scales with your Finger, and this does not return to its Equipoiſe, when the Finger is removed: If this be the Caſe, your Balance may indeed be right, as to the Length and Weight of the Arms of the Beam, but it can hardly be reſtored to an exact Equipoiſe, whence it is leſs fit to weigh any thing exactly.

269. But it is not enough to have known whether a Balance was juſt or defective: We muſt likewiſe be able to correct the Faults detected in it. You muſt then above all know the Cauſes of the Defects; that, by removing them, the perfect Exactneſs deſired may be obtained. Nay, the Aſſayer ſtands in greater Need of knowing how the Faults of a Balance are corrected, than the Manner in which the Balance is made; becauſe, by mending, he at laſt obtains the ſcrupulous Exactneſs requiſite in docimaſtical Ponderations. Let us then take this Point in hand. Firſt, it is a teaſing Fault in a Balance, when it cannot either be reduced to a Situation perfectly horizontal, or, when being reduced to it, and either of its Scales being lowered, it is not immediately reſtored to its firſt State, by the Removal of the Power that lowers it. This ſhews that the Axis upon which the Beam of the Balance is ſupported, is in the ſame horizontal Line with thoſe Points to which the Powers are applied. To correct this, take the Beam out of the Fork, and, with a Pair of Pincers, lower a little the ringed Extremities (*a b*) of the Arms, with ſuch Evenneſs however, that a Thread, extended from one Ring to the other, along the Length of the Beam, may be on either Side at right Angles with the Tongue of the Balance, which muſt be proved by applying to it a Square. 2. But if the Balance, put in *Equilibrio*, does not eaſily change its Situation, with a very ſmall

Weight added on one Side; it ſhews, either that the Axis is not ſufficiently acute, or that the Holes of the Fork in which the Axis turns, being too narrow, reſiſt to the Motion of it; or, in ſhort, that the Axis is placed too high above the horizontal Line, drawn from one of the Rings of the Arms to the other. The two firſt Faults are very eaſily mended, by either ſharpening the Axis or widening the Hole. As to the third Defect, as the Axis cannot be removed, the Rings muſt be elevated: Which may be done in the Manner mentioned (N° 1). 3. It is a Fault in a Balance, when, being equipoiſed, it does not ſtand the interchanging of the Powers; or if, the Powers being removed, it declines on either Side: This ſhews, when the Scales and Diſhes are equiponderous, that either one of the Arms of the Beam is ſhorter than the other, or the one out-weighs the other, or that the Defect proceeds from both Cauſes. Therefore, to correct it, you muſt firſt lift up the Balance unloaded, and, if it is not in *Equilibrio*, let the Equipoiſe be reſtored, by putting Grains of Lead into the Scale. Then put the ſmall Diſhes into the Scales, and if the Balance does not remain in *Equilibrio*, let the *Equilibrium* be again reſtored by putting granulated Lead into the ſmall Diſh, not into the Scale. This done, if the Diſhes can be interchanged, without altering the *Equilibrium*; it ſhews, that you muſt take as much matter from one of the Scales, with a Wheſtone or a File, as you have put Grains of Lead in the other, to obtain an *Equilibrium:* For one is heavier than the other: Which Inequality is moſt commonly occaſioned by Dirt, or Ruſt. But if you cannot interchange your ſmall Diſhes, and preſerve an *Equilibrium*, you may be ſure that one or the other of the Extremities of the Beam, and even that which goes down after the interchanging of the Diſhes, is more remote from the Axis than the other. Wherefore, this Arm muſt be made ſhorter: Which is done, by preſſing ſoftly, and a ſmall Matter towards the Axis,

272. As the Aſſayers' Scales hitherto (§ 263--271.) deſcribed, and made as delicate and nice as is requiſite, cannot without Detriment bear above two docimaſtick Centners, or Drachms; you muſt have another ſomewhat ſtronger Balance, that may be loaded with a few common Ounces, which ſerves to weigh the ſeveral *Fluxes*, the *Additions*, *Lead* and *Ores*, eſpecially thoſe of *Copper*, *Iron*, *Lead*, *Tin*, *&c.* Let this likewiſe be made exact, and ſuſpended on a Support.

273. As many kinds of *Weights* are uſed by Artificers that work in Metals, to weigh them, ſo many muſt the Aſſayer have at hand, becauſe he is much more taken up with his Art than any, and muſt not be obliged to conſume his Time in arithmetical Calculations, for the Reduction of his Weights. But the Weights which are properly called Aſſayer's Weights, are a thouſand times ſmaller than common ones; becauſe, the Portions of Metals or of Ores examined in docimaſtical Operations are extremely ſmall.

274. The Metallurgiſts, who extract Metals out of their Ores, uſe a Weight divided into a hundred equal Parts (they call them *Pounds*) the whole of which they call a *Centner*, or an hundred Weight. The Pound is divided into thirty two Parts called *half-Ounces*, (in *German* **Loth**); the half Ounce again, is divided into two Quarters, and the Quarter into as many Drachms, called in *German* **Quintlein**. There is hardly any further Subdiviſion of the Weights, uſed in large Works. However it is proper, that the Aſſayer ſhould alſo have a *Drachm* divided into two equal Parts; becauſe he muſt ſometimes have regard to ſuch minute Quantities. Finally, to be able to weigh all the Parts of a Centner juſt mentioned, you muſt have at hand as many different Weights, as are requiſite, to compoſe from them each of the Parts of the Centner.

You muſt therefore have at hand:

1	A Centner weighing	—	100	Pounds.
2	A Weight	—	64	
3	——	——	32	
4	——	——	16	
5	——	——	8	
6	——	——	4	
7	——	——	2	
8	——	——	1	
9	A Weight ½ Pound	ſ.	16	Loths.
10	—— ¼ ——	ſ.	8	
11	—— ⅛ ——	ſ.	4	
12	—— $\frac{1}{16}$ ——	ſ.	2	
13	—— $\frac{1}{32}$ ——	ſ.	1	
14	A Weight ½ Loth.	ſ.	2	Drachms.
15	—— ¼ ——	ſ.	1	
16	—— ⅛ ——	ſ.	½	

275. The Diviſions and Denominations of Weights hitherto given (§ 274.) are equally uſed by Aſſayers and Metallurgiſts; with this Difference however, that the *Centner* of Metallurgiſts contains one hundred common Pounds; whereas that of the Aſſayers contains only one real Drachm, to which the other Parts are afterwards proportioned.

276. As then the docimaſtical Weights are divided to ſuch a Degree of Minuteneſs (§ 275), and ſo vaſtly different from the common ones; the Aſſayer muſt be able to make them with his own Skill, which we muſt now teach him how to do.

277. Theſe Weights (§ 274.) are made of ſquare Silver * Plates, of ſuch a Size, as that the Mark of each different Weight, may be put upon them. Let

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* If you do not care to beſtow *Silver* on your Weights, thin Pieces of fine Solder will do as well.

us firſt take for a Baſis one Weight, being about two thirds of a common Drachm, and let it be marked (64. *lb.*) Then have at hand granulated Lead, waſhed clean, well dried, and ſifted very fine: Put as much of it in one of the ſmall Diſhes of the Aſſay-balance, as ſhall be neceſſary to equipoiſe the Weight (64. *lb.*) juſt mentioned, which is in the oppoſite ſmall Diſh. This done, take out of the Diſh the Silver-Weight, and put in the Room of it half of the granulated Lead; ſo that a perfect *Equilibrium* may be obtained. Then pour the granulated Lead out of each ſmall Diſh, and inſtead of it put another Silver-Weight already made, like the foregoing, being a little heavier than half of it, and mark it (32. *lb.*) taking great Care, that not the minuteſt Part of the granulated Lead remain in the ſmall Diſh. If this ſecond ſilver-Weight exceeds by much that of the granulated Lead being ſtill in the other ſmall Diſh; you muſt take a little from it, with a delicate thin File: And if it exceeds it but little, uſe a ſmall Whetſtone, that will rub off but a little at a time, comparing your Weights pretty often, till you render this perfectly equal to the granulated Lead. Then interchange the ſmall Diſhes; that, if the Balance has poſſibly been vitiated, or any Error committed, it may neceſſarily appear. Go on in the ſame Manner, till you have made all the ſmall Weights. But if you finally will have one entire hundred; add to the Weight 64. *lb.* one of 32, and another of 4. *lib*; and taking them together, make one larger *Silver* Plate of equal Weight with them, and mark it (100 *lb.*) Thus you will have a ſufficient Number of Weights, out of which you will be able to compoſe all the Parts of the Hundred, by intermixing them.

278. You will often want a centner-Weight larger han the common Drachm, which may likewiſe be ſily made of one Size, according to the Rules (§ 277.) ove preſcribed. However, it is proper that this eight be proportioned to the ſmaller Centner, and

to its Parts; that for Inſtance it ſhould be exactly the Double or Quadruple: By which Means the leſſer Centner, together with its Parts, ſerve to determine alſo the Parts of the larger.

279. You will find out, whether the Weights are made exact, or have contracted Faults in the uſing, by comparing the Centner, or its larger Parts, with the leſſer ones: For Inſtance, the whole Centner, with 64, 32, and 4 *lib.* the 64 *lib.* with 32 *lib.* and with two 16 *lib.* and ſo on. It is then proper to have two Weights of each peculiar Part of the hundred *lb.* Which is the more eaſily done, becauſe in the making of the Weights, it is a moſt tedious Work to determine the right Quantity of the granulated Lead: Which being once done, it is an eaſy Matter to prepare two Siver-Plates equipoiſing the ſame Quantity of granulated Lead.

280. Put theſe Weights (§ 277, 278.) into a ſmall Caſe or Box, that may be ſhut, and in which there are for each of them proper and neat ſmall Partitions contrived, and lined with Leather or Cloth: That every one may immediately be found, and that many of them being put together in one and the ſame Partition, may not rub againſt and wear out each other, whereby they are very eaſily ſpoiled.

Scholion. *In the making of the Weights* (§ 277.) *ſome uſe to determine the ſmalleſt of them firſt, and then to arrive at the hundred* lb. *by multiplying; but then an inſenſible Error committed in the ſmalleſt Weight, becomes very conſiderable, as it is multiplied over and over, and you loſe all your Labour. On the contrary, if you firſt determine the largeſt Weight, as ſome uſe to do; you have much ado afterwards to find out the ſmalleſt: For it is hardly poſſible to proceed with dividing into two, from* 100 *to* 25, *and more. This is the Reaſon why I begin from* 64 lb. *not making any Weights of* 50, *or* 25 lb; *becauſe they may eaſily be obtained by the Combination of the others.*

281. The common hundred Weights varies according to the different Places: For it often contains more than

dies, the ſpecifick Colour of every one appears very diſtinctly, when you rub it againſt a very black hard Stone. If then the Colours of two or more Metals to be aſſayed, are expreſſed by large lively Spots made near each other in the ſame Plane, after having rubbed them againſt the Surface of ſuch a Stone, you will by that Means eaſily diſcern their Difference, or their Likeneſs.

288. The Stone adapted for this Uſe (§ 287.) is called the *Touch-Stone*; which muſt have the following Properties. 1. It muſt be of the deepeſt Black, leſt the Tincture of the Metal ſhould be hindered, by ſpurious Rays of Light ſhining between them. 2. It muſt be capable of being pretty well poliſhed: For when too rough, the Colours of the Metals rubbed againſt it, cannot be neatly perceived: And if it is too ſmooth, the Metals are but faintly and ſlowly ſcraped by it, eſpecially *Gold*. 3. It muſt be neither too hard, nor too ſoft: For *Tripoly*, *Coal Duſt*, and *Tin-aſhes* rub off the ſmall metalline Cruſts: So that, in a ſhort Time, this Stone, though ever ſo hard, acquires too great a Smoothneſs: And when it is too ſoft, it is eaſily ground into a fine Duſt, and contracts Furrows. Therefore, black rough Marble, or black ſoft River-Pebbles, are excellent for that Uſe. They muſt be made into a quadrangular Priſm, about one Inch thick, and two or three Inches long; which is the moſt convenient Figure for that Purpoſe.

289. The Metals which are tried in the Manner mentioned, are *Gold*, *Silver*, *Copper*, when pure, or mixt among themſelves by Fuſion, in many different Proportions. But in order the better to find out the Purity and various Mixtures of theſe Metals, whenever they are to be examined; the Maſſes to be tried are compared with ſmall pure Maſſes of the ſame Metals, or of Metals mixt in a known Proportion, and deſignedly prepared for that Uſe, which are called Touch-needles. Now the aforeſaid Metals, both thoſe pure and thoſe mixt in different Proportions, are made into

Lamina's one Line broad, one fourth Part of a Line thick, and one Inch and a half long, upon each of which you engrave a Mark, indicating their Purity, or the ſeveral Mixtures of the Metals which they are made of.

290. Let us now ſhew the Manner of making theſe Touch-needles (§ 289); and firſt of all the Silver ones. Theſe muſt be tempered only with *Copper:* But the Proportion is determined by the Mark (§ 284.) divided into half-Ounces and Grains. Therefore, you muſt uſe for that Purpoſe one Mark of ſuch a Weight, as that it may conſtitute a ſufficient Maſs of Metal for the making of one Needle: Let it then weigh, for Inſtance, one whole Dram. Then weigh ſuch a Mark of the pureſt Silver, wrap it in a ſmall Paper, upon which you will write ſixteen half Ounces; which will ſignify, that the whole Mark of this Metal is the pureſt Silver. Make the firſt Needle with this Maſs. Next, weigh fifteen half Ounces of pure Silver, and one half Ounce of pure Copper; wrap them both together in a Paper, and mark upon it fifteen Ounces, which will ſignify, that there are in that ſmall Maſs fifteen Parts of pure Silver, and one of pure Copper. Make of this the ſecond Needle. Then add two half Ounces of Copper to fourteen half Ounces of pure Silver; and mark it fourteen half Ounces. Make a third Needle of this. Go on thus, and proportion the ſmall Maſſes of Silver and Copper for the making of the other Needles, and put Inſcriptions upon every one in the following Manner.

For Needle the		half oz. of *Silver*	half oz. of *Copper*.
	4th	13	3
	5th	12	4
	6th	11	5
	7th	10	6
	8th	9	7
	9th	8	8
	10th	7	9
	11th	6	10
	12th	5	11
	13th	4	12
	14th	3	13
	15th	2	14
	16th	1	15

Let then each of theſe Portions of Metal, as they are wrapt in a particular Paper, be put ſeparately into a new Crucible, never uſed for any Operation; and, adding a little Borax, melt them in a very quick Fire, which muſt be well kindled before with Bellows; or, what's ſtill better, throw them ſuddenly into a white hot Crucible, and, ſo ſoon as they melt, ſtir them with a dry wooden-Peg, burnt at the End, and pour them immediately into an Ingot. This Fuſion may as well, and almoſt more conveniently, be made with a cementatory Tube (§ 258). Next to this, wrap each ſmall Maſs, grown cold, into its Paper again, to avoid Confuſion, and again try them ſingly in the Balance. If they ſtill weigh a whole Mark, they are good: But if there is any conſiderable Deficiency in the Weight; it is a Sign that your Fire, having been too weak, or of too long a Duration, has conſumed as much Copper, as is wanting in the Weight: Therefore, inſtead of this ſmall deficient Maſs, another muſt be made in the ſame Proportion. Then with a Hammer, make a Needle (§ 289.) of each of theſe ſmall Maſſes, making them a little red hot, when the Metal begins to grow ſtiff under the Hammer. This done, engrave upon every one of theſe Needles the Number of half Ounces of Silver which they contain; that is, upon the firſt, 16; upon the ſecond 15; and ſo on. Then pierce them at one End, and running a

Silver-Wire through their Eyes, collect them in Order, according to their different Numbers. Theſe are called Silver Touch-Needles, but they call the ſeveral Temperines of Silver with Copper, *Allays*.

291. Some determine the Proportions of their Needles by half Loths: Others uſe ſtill ſmaller Diviſions, the Compoſitions and Numbers of which may be eaſily known from (§ 290). But you can hardly diſtinguiſh any thing of Silver-Allay, by your Needles, when you divide beyond half Loths.

292. You may alſo add to theſe Silver-Needles (§ 290.) one made of pure Copper: For with theſe you may at the ſame Time find out the Purity of the Copper, or its various Mixtures of Silver.

293. In *Holland* they uſe the Mint-Mark (§ 285) divided into Grains, for the making of Needles. But then, the firſt Needle, made of pure Silver, is ſaid to be twelve Penny-weights. The ſecond is made of eleven Penny-weights and eighteen Grains, by the Addition of ſix Grains of Copper. The third is made of eleven Penny-weights and twelve Grains, with twelve Grains of Copper; and ſo on: the Proportion of the Silver decreaſing always ſix Grains at a Time, that is, one quarter Part of a Penny-weight, and that of the Copper being always increaſed in the ſame Proportion; till at laſt the Weight of the Silver is diminiſhed to one Penny-weight, and the Quantity of the Copper augmented to eleven Penny-weights: Which Proportion conſtitutes the laſt Needle, beyond which you are not to proceed.

294. However, it is needleſs to go through the whole Series of the Needles, by ſo ſmall Progreſſions, to the very laſt. It is enough for us, to have indicated quarter Parts of a Penny-weight to one Needle of nine Penny-weights (§ 285), and the half-Ounces to one Needle of ten Semi-ounces (§ 284); for afterwards, you cannot accurately diſtinguiſh Proportions ſo very delicate, in the following Needles.

295. *Gold*, when you are to make Gold-Needles, muſt be mixt either with Silver alone, or with Silver

and Copper variouſly intermixed. But this Mixture is called *allaying*, or *carracting*, and is determined with a Mark divided into Caracts, or Weights of two ſixth Parts of an Ounce (§ 286). There is nothing to be obſerved about the making of theſe Needles, beſides what has been already ſaid of the Silver-Needles (§ 290), except that the Proportions of the Weights are determined in another Manner. Theſe Needles are made according to the following Diviſion and Order. They all weigh eight Ounces, or one Mark.

The firſt is entirely made of pure Gold.

2d	23 Car. 6 Gr.	Pure Gold.	6 Gr.	Pure Silver.
3d	23 Car.		1 Car.	
4th	22 Car. 6 Gr.		1 Car. 6 Gr.	
5th	22 Car.		2 Gr.	
6th	21 Car. 6 Gr.		2 Car. 6 Gr.	
7th	21 Car.		3 Car.	
8th	20 Car. 6 Gr.		3 Car. 6 Gr.	
9th	20 Car.		4 Car.	
10th	19 Car.		5 Car.	
11th	18 Car.		6 Car.	

The Decreaſe goes on thus by whole Caracts, till the Weight of the Gold is arrived at one Caract, and that of the Silver at twenty three: for after the ninth Needle, you cannot make ſo exact a Diſtinction of the half Caracts. Now, this Mixture of Gold with Silver is called *the white Allay*.

296. But when Copper together with Silver enters into the Mixture of the Gold, it then is called *a mixt Allay*: This is compoſed in the ſame Manner as the foregoing (§ 295), except only that thoſe Portions, which in the firſt Caſe were pure Silver, here conſiſt of Copper and Silver. Therefore, you have here again a double Series: For you mix either two Parts of Silver and one of Copper, or two Parts of Copper and one of Silver; for Inſtance:

The firſt is of pure Gold.

	Of pure Gold.	Of pure Silver.	Of pure Copper.
2d	23 Car. 6 Gr.	4 Gr.	2 Gr.
3d	23 Car.	8 Gr.	4
4th	22 Car. 6 Gr.	1 Car.	6
5th	22 Car.	1 Car. 4 Gr.	8
6th	21 Car. 6 Gr.	1 Car. 8 Gr.	10
7th	21 Car.	2 Car.	1 Car.
8th	20 Car. 6 Gr.	2 Car. 4 Gr.	1 Car. 2 Gr.

And ſo on, as in the foregoing.

297. If in the Table juſt mentioned (§ 296), you take pure Copper, inſtead of pure Silver, and Silver inſtead of Copper; this gives you a third Series of Golden-Needles. And you will have a fourth, by mixing with Gold equal Quantities of Silver and Copper, in the ſame Proportions mentioned (§ 296).

298. The Allays of Gold hitherto explained (§ 295, *and foll.*) are very much in uſe. However, it is plain, that Workmen may eaſily employ an infinite Number of other Variations; which, being compared with thoſe above-mentioned, may be diſtinguiſhed in a thouſand different Ways, by an experienced Man: So that it is neither poſſible, nor neceſſary, to imitate them all.

299. But leſt the Golden-Needles (§ 295 *and foll.*) ſhould be too expenſive; they may be made much ſhorter than the Silver ones (§ 289, 290), and be ſoldered to Plates of Copper; that they may be ſufficiently long for Uſe.

300. Now, if you light upon a Metal (§ 289), which you think wants to be tried upon the *Touch-ſtone*; wipe it firſt with a clean Towel, or Leather; that you may ſee the true Colour of it: for from this you may, in a Manner, judge before-hand, what Metal it is, and how much, or with what other Metal it is mixt. Then chuſe a convenient and not over large Part of the Surface of your Metal, and at ſeveral Times rub it ſtrongly againſt the *Touch-ſtone*; that, in caſe a deceitful Cruſt ſhould have been laid upon

the Metal, it may be ſcraped off by a ſtrong Friction: which however may be done ſtill quicker with a Grind-ſtone, or a delicate File, if you have them at hand. Then wipe a flat and very clean Place (§ 288.) of the Touch-ſtone, and rub againſt it the ſame Part juſt mentioned of the Surface of your Metal over and over; till the flat Part of the Stone be equally and neatly covered with a metallick Cruſt, one Inch long, and one Line and a half broad. This done, chuſe the Needle, that you ſhall judge anſwers neareſt to the Metal rubbed; which Choice is learned by frequent Practice. Then wipe the loweſt Extremity of this Needle very well, and rub it againſt the Touch-ſtone, as you did the Metal, by the Side of the firſt Plain, and in a Direction parallel to it. If you can find no Difference between both Plains; you may pronounce with Probability, that the Metal to be tried is of the ſame Temperature, as the Needle you have compared with it: which Temperature is ſhewed by the Number ingraved (§ 290. *and foll.*) upon it. But if you find a Difference between the Colours; chuſe another Needle, in caſe you ſhall find the Metal of a deeper or a lighter Colour than the firſt Needle: Thus you will at laſt find a proper Needle, anſwering to the Temperature of the Metal; or at leaſt you will be able to judge, that the Allay of Metal is extraordinary, and cannot be determined by your Needles.

301. Mean while, as not only the Surface, but alſo the whole Maſs of the Metal may be dyed with a ſpurious Colour, which may be produced many different Ways; you may eaſily ſee, from the Colour of any Metal compared with your Needles, that you can paſs no certain Judgment upon it, unleſs you know that the Gold and Silver are mixt, and what the Metals are wherewith they are ſo mixt: whether, for Inſtance, it is Gold and Silver, Silver and Copper, or all theſe three perfectly pure, without any Mixture of another Metal. For, in this Caſe, the Compariſon of the Colours with thoſe of your Needles, may inform

form you of their Temperature. Nor can, however, this Determination be made exact to a few Grains, by this Method.

302. But if the Colour of the Metal has been altered (§ 57, 71, 83, 88.) by Tin, Arſenick, Zink, *&c.* the Workman may be deceived by the Colour, ſo as to take for pure Gold or Silver, what is not ſuch by the greateſt Part. You find out the Deceit with *Aqua Fortis*, when the metallick Maſs is of the Colour of Gold; and with *Aqua Regis*, when it is like Silver: for the firſt of theſe Liquors diſſolves all Metals, *Gold* excepted; and the other likewiſe all Metals, but *Silver*. In ſuch Caſe then, you pour upon the metallick Streak, or thin Cruſt rubbed upon the Touch-ſtone, one ſingle ſmall Drop of either of theſe diſſolving Liquors, and extend it gently with a Feather; if it is neither Gold nor Silver: the whole Streak will be conſumed: but, if there is any Gold or Silver in it, this remains undiſſolved, and ſhews another Colour; becauſe the other Parts have been ſeparated from it by the Solution. Take care however, when you make uſe of theſe *Menſtrua*, that there is no oily Mixture with them; becauſe this would render them of no Effect.

303. Beſides this, you are to obſerve the following Particulars concerning the Uſe of the Touch-ſtone. 1. Gold and Silver, pure and ſeparate, or both mixt together, without any other Matter added to them, when made white hot in the Fire, not only preſerve their Colour, but alſo entirely recover all their Splendor there, when tarniſhed, not loſing the leaſt Part of their Weight (§ 6, 7): on account of which Quality the *Caratura alba*, or white Allay, is diſtinguiſhed from all the others. But if you have not the Liberty to try the whole Maſs in the Fire; you may make only a ſmall Part of it white hot, with a blow-Pipe (§ 258). 2. If you find a Needle, whoſe Colour agrees with that of the Metal to be tried; both the Streaks imprinted upon the Touch-ſtone muſt undergo Changes altogether the ſame, when *Aqua Fortis*,

Fortis, or *Aqua Regis* is poured upon them; that you may thus be certain, that there is no Fraud at Bottom: otherwiſe, you are not to doubt, upon any Account, your being deceived by a falſe Colour. 3. All Gold rendered brittle, when compared with the Needle upon the Touch-ſtone, appears leſs pure, than it is indeed found to be, by an accurate docimaſtical Examination: and, on the contrary, all Silver rendered brittle has the Whiteneſs of pure Silver in a higher Degree. Nor is it difficult to find out the Reaſon of this Difference: for the Bodies which make *Silver* or *Gold* brittle, are only a few Metals and Semi-metals, all of a very bright white Colour: ſuch as *Tin*, *Lead*, *Iron*, *Regulus of Antimony*, *Biſmuth*, *Zink*, and *Arſenick*. Now theſe dilute the yellow Colour of *Copper* and *Gold*, or change it into white: ſo that the Colour of the Copper mixt with Silver is then hidden; whereas Gold, on account of theſe Mixtures, appears to have a great Deal of Silver in it. 4. In a white Allay *Aqua Fortis* does not diſcover (§ 302.) the Preſence of *Silver*, from twenty three to ſeven Carats (§ 295), becauſe *Aqua Fortis* does not ſeparate *Silver* from *Gold*, unleſs the Maſs contains three times more *Silver* than Gold. 5. Metallick Streaks or Cruſts, which have been imprinted a while upon the Touch-ſtone, cannot be compared with freſh ones: for their remaining long upon it, commonly occaſions an Alteration in the Colour. 6. *Silver*, when tempered with *Braſs*, appears whiter, than it would, if mixt with a like Quantity of Copper: but as it may then be rendered ſufficiently ductil by a proper Operation; you will hardly be able to find out the Fraud with the Touch-ſtone, unleſs you make a ſecond Time the Compariſon with a Needle of the ſame Colour, having previouſly poured *Aqua Regis* (§ 302.) upon the metallick Cruſt, laid by rubbing on the Touch-ſtone. Nor are the Touch-Needles tempered with Braſs of any great Uſe here; becauſe this artificial Metal is ſometimes more, ſometimes leſs yellow. 7. If the Metal, applied upon the Touch-ſtone, by rubbing, does not appear neatly enough, lick it over with Spittle not frothy, and then the Colours will be more lively reflected.

304. Beſides the Utenſils hitherto deſcribed (§ 168, 301) you muſt have a convenient Place for the performing of the docimaſtical Operations. You muſt have a Chimney, large enough to place the Furnaces, and capable of quite confining the Fumes; which, tho' not all mortal, are nevertheleſs always hurtful, in almoſt all Operations when they can come out freely. But as theſe acid Fumes corrode the Metals themſelves, it is not proper to keep in the Laboratory ſuch metallick Utenſils, as muſt be preſerved very clean; for inſtance the Scales, with their Weights, the Touch-Needles, &c. which muſt be kept in a cleaner Place: nor muſt you keep there many different *Menſtrua*, except they are in Veſſels perfectly cloſed: for ſome of them, by ſending forth their Vapours, change the others, and are mutually altered by them; ſo that you can no longer make any exact Experiment with the ſame. Moreover, as you muſt frequently obſerve very minute Bodies, and their ſeveral Changes in and out of the Fire; the Laboratory, which in the firſt Caſe muſt be darkened, in this muſt be rendered very bright: which may be eaſily obtained, by hanging up thick or black Curtains againſt the Windows.

CHAP. IV.

Of compound Minerals.

Of ORES.

305. HAVING in our firſt Chapter given an Account of the ſimpler Minerals, and in the Second that of their principal Actions upon each other, as far as they can be ſo diſpoſed by no great

Art; we may now underſtand and explain the Nature of thoſe Bodies, which, being compoſed of the foregoing, are found natural in the foſſile Kingdom. The Knowledge of theſe, though we could hitherto give it only hiſtorically, has nevertheleſs a vaſt Utility in the exerciſing the practical Part of Aſſaying; for he that is well imbued with it before-hand, may very well diſpenſe with many vague Experiments, which he is obliged to go through, when altogether a Stranger to the ſeveral natural compound Bodies.

306. But the uſeleſs Deſcriptions given by many Authors and derived moſt of them from accidental Properties; the Difficulty of obtaining the beſt Specimens from different Countries; the Variety with which Minerals are mixt together in their minuteſt Particles (§ 32); in ſhort, the Difference of the Works of Nature, and of thoſe of Art, though they are made of the ſame Principles united in equal Proportions; render this Part of natural Hiſtory equally difficult and defective. Add to theſe the Variety of outward Figures wherein Nature ſeems to delight ſtill more in the mineral, than in the vegetative and the animal Kingdoms.

307. Nor is the ſpecifick Gravity of any great Help, in the diſtinguiſhing of compound Minerals. For, 1. when more than two Bodies of different ſpecifick Gravities are mixt together, you can detect nothing by an hydroſtatical Calculation; becauſe a compound Maſs of the ſame ſpecifick Gravity may be produced by many ſimple Bodies, very different from each other, and mixt in a thouſand different Proportions: Now the ſame is in reality found in the mineral Kingdom, as is ſhewn by docimaſtical Operations. 2. The accidental Matters inherent to Minerals, and the very Air impriſoned in the ſmall Cavities and Clefts of ſeveral Ores, hinder an exact Ponderation, and now and then render it very difficult. 3. The ſimple Stones, which, being joined with almoſt all compound Minerals, are not only of infinite Variety, as to their ſpecifick Weight, but ſome

are almoſt as ponderous as Metals themſelves: ſuch are a great many Species of Spaad.

308. However, I would not have the ſpecifick Gravity, nor the Figure be altogether overlooked, but rather made uſe of with the other Characteriſticks; though no conſtant and accurate Judgment can always be drawn from theſe alone.

309. But our Deſign being to lay down the Principles of the Art of Aſſaying; it will be neceſſary only, to mention the Characteriſticks and diſtinguiſhing Marks of compound Minerals, as they are the moſt frequent Objects of the ſaid Art (§ 2), and to ſhew their conſtituent Parts, as far as they make themſelves known, together with the Diſpoſition of the whole Body with ſeveral *Menſtrua*. It is likewiſe evident, that we cannot here mention all Ores without Exception, but that we muſt only chuſe thoſe that are leſs compound, or thoſe at leaſt which are more frequently met with.

310. We ſhall refer every compound Mineral to the Claſs of that Simple, of which it contains the greateſt Part in itſelf; except however *Stones*, and ſimple *Earths*: for if the Claſſes of theſe were to be determined from their predominant Parts; the Number of the Ores to be referred to that Claſs would be by much the greateſt.

Scholion. *For Inſtance, let us ſuppoſe, that there are in a Lump, ſix Parts of Copper, and one of Sulphur, a very ſmall Quantity of Arſenick, and twenty Parts of Quartz or Flint-ſtone; we ſhall claſs this compound Body with the Copper-kind, and ſo on.*

311. But we ſhall call a Mineral *proper* to that Simple, which makes the greateſt Part of it (§ 310), and improper to thoſe which it contains in leſs Quantity: However, they are contained in it in ſuch Manner, that they indeed enter into the Mixture of it, and muſt always accompany it wherever ſuch Mineral is found. Finally, we ſhall call it accidental to thoſe Simples, which enter not into the Mixture of it, being only adherent to the Out-ſide: Wherefore, they

may be or not be found with the Mineral now mentioned, and yet this Mineral remain ſtill the ſame.

Scholion. *Let us clear this Matter by the foregoing Example* (Schol. § 310). *The Mineral ſuppoſed there, containing Copper in the greateſt Part, is called* proper *to Copper. But ſo long as Sulphur and Arſenick are mixt together with the Copper, and render it of a particular Species, this Mineral, on account of the ſmall Quantity of its ſulphureous and arſenical Parts, is ſaid to be* improper *to them. Finally, the Stones or other Bodies, placed about or among that Mineral, are called* accidental *to it, as they are no conſtituent Parts thereof, and it might ſubſiſt without them.*

Of Sulphur and ſulphureous Minerals.

312. *Mineral Sulphur*, or *common Brimſtone*, when free of all foreign Mixtures, is of a ſolid, friable Conſiſtence; yellow, made up of large Maſſes, and more or leſs half-tranſparent; it burns, makes a bluiſh Flame, with a ſuffocating acid Vapour (§ 22), and thus is entirely conſumed: Being put upon a gentle Fire, and in cloſe Veſſels, it melts without taking Fire; and, when melted, changes its Colour into a bright Red: it no ſooner grows cold again, but it reſumes its Solidity and yellow Colour. It is compoſed of the pureſt inflammable Principle (§ 24), and of a much greater Quantity of Acid of *Vitriol* (§ 22): on which Account it ſinks in Water, being much heavier than pure Oil. The Chemical Analyſis, and the Production by Art of true Sulphur, out of the two Principles juſt mentioned, confirm what has been ſaid of it.

313. In this State (§ 312.) native Sulphur is digged out of the *Earth*; though not ſo very frequently: it is likewiſe brought in ſuch a State by Waters, which on this Account are called particularly medicinal, and it applies itſelf to the Walls of the Springs.

314. It is frequently found mixt with ſimple Earths and Stones; varying its Dye, and being ſometimes

white, ſometimes grey, yellow, or of other Colours, belonging to the Bodies mixt with it.

315. Whenever *Sulphur* is tinctured with a dark, or bright Orange or red Colour, this always betrays Arſenick in it: Wherefore, Sulphurs thus coloured are not true, nor very valuable.

316. The moſt frequent and almoſt the *proper* Mineral of *Sulphur* is the *Pyrites flavus*, or yellow *Pyrites*. This, when free of all heterogeneous Matters at the outſide, and bright, has all the Appearance of poliſhed Braſs, and is more various as to its Form, than any other Mineral: however it is moſt commonly found of a globulous Form, then of a cubical hexagonal, both regular and irregular Figure. It is ſolid; unleſs it be rendered ſoft by a Mixture of ſoft Stones and Earths: when ſtruck with a Steel, it gives Sparks like a Flint: when brought near a gentle Fire, it ſoon burſts, with a crackling Noiſe; and emits ſmall Flames almoſt ſulphureous: it changes its yellow Colour into a dark red, and its neat Surface into a duſty one. It is very rich in Sulphur, and contains one quarter, ſometimes almoſt one third Part of it. Moreover, there is always a Quantity of Iron lurking in it; its ſulphureous Part is ſometimes greater, ſometimes leſs: and *Henckel* has found that it alſo contains a kind of *Earth* not metallick, and in a various Proportion as to the other Parts: which makes us eaſily gueſs, that the ſpecifick Weight of the Pyrites muſt be very various. The Author juſt mentioned has, in his Treatiſe on Pyrites *, given us a very ample Hiſtory of this Mineral, together with a very accurate Analyſis of it.

317. There are very few Minerals altogether deſtitute of Sulphur; but as the extracting of it would never pay the Charges, and they beſides contain Metals and Semi-Metals in a greater Quantity; for this

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* *Pyritologia*, oder *Kieſs Hiſtorie*, &c. gefertiget von D. *Johann Friedrich Henckel*. *Leipzig*. 1725, in 8vo.

Reaſon, we ſhall mention them in thoſe Places, to which they properly belong (§ 310, 311).

318. We may alſo refer to this Claſs all the inflammable Minerals, that differ from Sulphur ſtrictly ſo called (§ 312.) by the Quantity and Quality of their Acids. Such are *Naphta* and *Petroleum*, that diſtil from *Stones*, or ſwim upon the Waters of Fountains. They differ hardly among themſelves, and are ſometimes very limpid and thin, ſometimes yellow and thick. But when theſe Matters are grown very thick, and have aſſumed a dark Colour, they are called *Bitumen*; *Pix Judaica*; *Aſphaltum*: and when at laſt grown harder, they turn into a Stone called *Gagates* or *Jeat* *. There occur beſides, other the like Names of ſulphureous Matters, which, however, ſeem hardly to ſignify other Concretes, different from thoſe juſt mentioned.

319. The very ſame (§ 318.) oily Mineral, when it hardens, and adheres to a ſtony Matrix, becomes that kind of foſſil Coal, called *Stone-coal*, *Quarry-coal* or *Sea-coal* †: which is a black concrete Body, eaſy to be cleft, conſiſting of Lamina's, and bright: much heavier than the foregoing (§ 318); not quite ſo quickly inflammable, but preſerving its Flame, when once kindled, longer and more violently than any other Fuel; leaving, after it is burnt, not ſo much Aſhes, as a Maſs half ſcorificated, blackiſh, ſpungy, and often containing a yellow Pyrites (§ 316.) in it.

320. *Amber*, called in Latin *Electrum*, *Succinum*, of a blackiſh, dark yellow Colour; half tranſparent, frequently very tranſparent; light; ſinking however in Water; very hard, ſo as not to ſoften at the Heat of boiling Water; melting nevertheleſs in a ſtrong

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* Of which Kind is the greateſt Plenty in ſome Parts of *England* and *Scotland*, known by the Name of *Kennel coal*, *Staffordſhire-coal*, and *Scotch coal*: out of the firſt ſeveral curious Veſſels are turned and carved, as of *Amber*, of which *Jeat* is a Species, and may be called black *Amber*.

† Which is the common Fuel in *London* and the maritime Parts of *England*.

Fire, foaming, and yielding a ſolid acid Salt, belongs alſo to this Claſs. It diſſolves, by a Chemical Diſtillation, into Oils, which are thin at firſt, and by degrees become thicker, and into an acid ſolid Salt: Theſe Oils have ſo much Affinity to *Naphtha* and *Petroleum* (§ 318), that we ſee, if not always, at leaſt moſt frequently, Apothecaries and Druggiſts uſe them in room of theſe natural Foſſils. The *Caput Mortuum* remaining after the Diſtillation, is not unlike *Bitumen* (§ 318), and is even ſold under that Name.

Of Arſenick, and arſenical Minerals.

321. The Cryſtalline, pure Arſenick deſcribed (§ 17) *, is got out of the Mines under the ſame Form, and looks white and duſty: however it is very ſeldom found natively ſuch.

322. The ſame (§ 321.) is digged out under the Form of a black or aſh-coloured Stone, which being broken when freſh taken out, is within of a bright bluiſh White, which however, being expoſed to the open Air, becomes dark and blackiſh in a few Days.

323. Next to this the white Pyrites, which is heavy, bright, ſtriking Fire againſt a Flint, and of a Figure altogether irregular, contains a very great Quantity of Arſenick, of Iron but little, more of Earth not metallick, and is moſt frequently found in Mines.

324. *Orpiment*, which is a Mineral of a Golden Colour, filled here and there with ſmall Maſſes of the Colour of Cinnabar, eaſy to be cleft, made up of Flakes, ſoft with ſome Tenacity, bright when broken, contains a great Deal of Arſenick, leſs of mineral Sulphur (§ 312): wherefore, it burns dark in the Fire, giving a whitiſh blue Flame, with a moſt thick white

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* *Arſenick* is vulgarly called in Engliſh *Rats bane*, and from its Colour is diſtinguiſhed into the white and yellow Rats bane, being the Poiſon uſually employed for deſtroying Rats.

Smoak. It melts as ſoon as it burns; when melted, if you pour it upon a clean Iron or marble-Table, growing cold, it turns into a ſolid Body, of a dark red Colour, brittle, bright, and half-tranſparent [*]: However, there remains upon it a Cream which is of a leſs fluid Nature, like imperfect *Scoriæ*, which being burnt in a great Fire, ſeparates into Earth. It is digged out in *Hungary*, and in the *Eaſt Indies.*

325. *Cobalt* belongs to the ſame Claſs. It is a ponderous Mineral, finely ſtriated, or ſometimes granulated, ſometimes alſo ſmooth at the Outſide, ſometimes of a light greyiſh, almoſt ſemi-metallick Colour, and ſometimes of a dark blackiſh Dye. It contains a great Deal of Arſenick, and a good Quantity of a certain fixt Earth, which being melted with Flints and fixt Alcali, turns into Glaſs, of the fineſt Blue, inclining howſoever to the violent Colour called *Smalt* [†]. Beſides, *Cobalt* moſt commonly contains Biſmuth (§ 15.) There are alſo many different Minerals called *Cobalt*, which nevertheleſs have Properties altogether different from thoſe juſt mentioned.

326. However, the Mineral called Flower of Cobalt, which is finely ſtriated, not very compact, and on this Account lighter than the foregoing (§ 325), and of a fine red purple Colour, belongs likewiſe to the *Cobalt* kind. For it is a very arſenical Mineral, ſo that it loſes above one half of its Weight in the Fire; but you may afterwards melt a great Quantity of *Biſmuth* out of what remains: and this beſides gives

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[*] And when it hath been thus melted, and of a Vermilion-Colour, it is called *red Arſenick* or *Sandarach.*

[†] The *Stone-blue*, or *flaky-Blue* for ſprinkling upon Wood freſh painted over, and the *Powder-blue* uſed in waſhing Linnen are Preparations of this Mineral; and the Manufacturing of it brings in great Profits in ſome Parts of *Germany*; but if our Engliſh Mineraliſts were curious in their Reſearches, they might certainly find both Cobalt and Biſmuth-Ore in *Cornwall*, and other Parts of *England:* there having been formerly ſent to the Royal Society Specimens of theſe Ores, among Specimens of Tin and other Ores. See the Note (§ 407.)

Glaſs the azure Colour, as the other true Cobalts do. On which Account it is true *Cobalt*, though outwardly it ſeems to differ very much from the common Sort (§ 325). It has indeed *Cobalt* (§ 325), for its Baſis, and ſeems to be produced by it, by a Germination as it were like that of Plumoſe Allum.

327. Theſe (§ 325, 326.) are the principal Species of true Cobalt, which all agree in this Point, that they have a very great Quantity of Arſenick in them: wherefore they are here referred to the Claſs of arſenical Minerals, though they ſometimes have that Difference from other arſenical Bodies, that, after the Sublimation of the Arſenick, they leave a *Caput Mortuum*, which tinges white Glaſs of an azure Colour. There are likewiſe many other Minerals, which they commonly call *Cobalt*. But as they are totally different from the true Cobalt, and even do not contain the leaſt Sign of Arſenick; for this Reaſon, and to avoid Confuſion, they deſerve to be expelled out of the Claſs of *Cobalt*.

328. Neverheleſs, there is a certain Mineral, that deſerves to be referred to this Claſs: it is rich in Arſenick, ſomewhat like Cobalt (§ 325), of a grey reddiſh Colour, it looks like a Semi-metal; it contains alſo a little Copper, and a little Sulphur; the *Germans* call it *Kupfer Nickel*.

329. There are alſo a great many other Minerals, which, on account of the Arſenick contained in them, are likewiſe referred to this Claſs. But as there is in them a greater Quantity of Metal than of Arſenick; for this Reaſon, they ſhall hereafter be reckoned among other Claſſes, as being improper (§ 311.) to Arſenick. I ſhall only add, that Arſenick makes itſelf known in all Minerals, by its white Smoak, and by its fœtid garlick-like Smell, when you put them upon burning Coals, or in a ſmall Veſſel made white hot in the Fire.

330. Finally you are to obſerve here, that Arſenick lies hidden in a great many ſimple Stones and Earths, eſpecially thoſe that ſhine and adhere

ſtrongly to them; and that when agitated by a violent Fire, it renders them for the greateſt Part volatile. The famous *Hankel* has obſerved, that it ſometimes lies hidden in marly and clayey Earths. See his *Pyritolog.* p. 611.

Of ORES *in general.*

331. When Metals and Semi-metals are penetrated with Sulphur and Arſenick, they always loſe, either that univerſal Character which is common to all Metals and Semi-metals, or that which is peculiar (§ 517.) to them alone. *Lead* and *Tin*, confounded with *Sulphur*, not only loſe that Character which is common to all Metals, *viz.* their Malleability, but are alſo deprived of the Properties peculiar to them, that is, when in a certain Situation in the Fire: for then, they both require a much greater Fire to be melted, than they would, if they had been free from Sulphur, and loſe beſides their Colour. The pureſt granulated Silver, confounded with Sulphur, retains its Malleability, Fuſibility, and the other Properties that are common to all Metals; but it loſes thoſe that are peculiar to itſelf: for its moſt white Colour changes into that of Lead; its hard Conſiſtence turns into the Softneſs of the ſame Metal; and finally, when it is but a little heated in the Fire, it then, if pure before the Fuſion, melts ſo ſoon as it grows red. But metallick Bodies are moſt commonly in that State naturally, except *Gold* alone.

332. Natural Concretes, of Metal or Semi-metal, mixt with Sulphur or Arſenick, or with both together, are called *Ores.* But when ſuch Alliances are made by Art, we then ſay that the Metals or Semi-metals are reduced to the State of Ores.

333. As, therefore it has been found hitherto, that the Cauſes of this particular ſtrange Form (§ 331.) given to metallick or ſemi-metallick Bodies, reſide in the Sulphur and Arſenick incorporated with their Subſtances; it would ſeem to be an eaſy Matter, to imi-

tate (§ 332.) by Art natural Concretes of this Kind: and it indeed has ſucceeded very well with ſome. Thus for Inſtance, the Silver vitreous Ore, the Ores of Mercury, and of *Regulus* of Antimony, may, by Art, be rendered perfect and like the natural ones; if to Silver you join Sulphur, or *Regulus* of Antimony by Fuſion, and to Mercury by Trituration and Sublimation. But the other Ores have not hitherto been ſo well imitated by Art: nay, this gives Birth to Products very different, though you uſe the ſame Ingredients, ſuch as may be fetched out of natural Bodies, and even in the ſame Proportion. But the Reaſon of this Variety, ſeems to be in the Manner and Time, in which *Arſenick* and *Sulphur* are by Nature joined with Metals or Semi metals not yet thoroughly tried, and ſometimes perhaps, when there is another Body, either not known at all, or not ſufficiently known: ſuch is the Earth containing no Metal in the true Pyrites and Cobalt (§ 316, 325), the Nature of which is not yet tried, with a ſufficient Degree of Certainty.

334. *Ores* (§ 332.) are diſtinguiſhed by Aſſayers, into fuſible, refractory, and not fuſible at all, according to their relative Diſpoſitions, with regard to the Fire and the *Menſtrua*. Thoſe are called fuſible, which, either by Means of a middling Fire only, or by adding a fit *Menſtruum* to them, melt eaſily, and as far as is neceſſary to obtain the Fuſion of a Metal or Semi-metal. The Refractory are thoſe, which require a very ſtrong and laſting Action of the Fire, to be melted in the requiſite Manner. But when they cannot be melted in the moſt violent Fire alone, and require the additional Action of a *Menſtruum*, to be put in Fuſion, they are called not fuſible. But it is plain enough, that there are ſtill many different Degrees, in each of theſe Claſſes.

335. The Reaſon of the Diſpoſition of *Ores* in the Fire, and with regard to the *Menſtrua*, lies hidden either in the Nature itſelf, or, as they call it, in the Eſſence of the Ore, or in the Nature of ſome Body

accidentally reſiding in it. But this Body again, has this Property of itſelf, or at leaſt is ſuch relatively to this or that Ore to which it is adherent.

336. As we are here upon *Ores* in general, we ſhall only touch upon thoſe Things, which, by their Preſence, render almoſt all Ores refractory, or altogether unfuſible. But we ſhall mention in our practical Part, when we treat of Ores in a more ſpecial Manner, the Things which produce this Effect, only with regard to ſome particular kind of Ore. All Ores lie hidden in Earths, Stones, or in other Ores, as in Matrices: if then theſe Matrices of themſelves melt in the Fire with very great difficulty, or not at all; the Ore contained in them, may indeed of its own Nature be put in fuſion; but yet it cannot be thus delivered of its Matrix, becauſe this is not fuſible. Such are for Inſtance iron-Ores, which by their Nature are always difficultly melted, and on this Account render other Ores difficult to be put in Fuſion, when they are naturally intermixed with them. It is the ſame with almoſt all the *Stones* and *Earths*, a few only excepted, which are ranked among the vitrificable ones: nor are theſe all of them very eaſy to be melted: for though they are put in Fuſion by Fire; they moſt commonly become at the ſame Time ſo clammy, that they hinder the Precipitation and Excuſſion of the ſmall metallick Maſſes. The Lime-Stones (§ 30), and thoſe that are not affected by Fire (§ 31), render the Ores intermixt with them moſt ſtubborn of any; ſo that they cannot be perfectly melted with Fire alone, even the moſt violent. Of theſe two the latter are ſtill worſe than the former. What we have hitherto ſaid, is equally underſtood of all Ores, whatſoever they may be.

337. Some of the Stones juſt mentioned (§ 336.) are much lighter than the Ores intermixt with them; ſo that theſe may be eaſily removed, either by only pounding, waſhing and extinguiſhing them in Water, or by a previous Calcination, leaving the weightier Particles of the Ore at the Bottom of the

Veſſel or Trough. Theſe kinds of Ores are called decantable, (in German 𝔖𝔠𝔥𝔦𝔢𝔡𝔦𝔤𝔢.) They are known to be ſuch: 1. from the great ſpecifick Gravity of the Ore, which ſhews us that the metallick Maſſes, adherent to its Matrix, are large and ſolid, not too ſmall and diſperſed. 2. From the Lightneſs of the ſtony Matrix. 3. From the Brittleneſs of the ſame, either natural or procured by burning it, or by extinguiſhing it in Water, which Brittleneſs renders the Comminution eaſy. In this Caſe however, it is proper that the Ore itſelf be ſufficiently fixt, and do not fly away by burning, or at leaſt that it ſhould thus melt into ſmall ſpheroidal Maſſes. Among ſimple Stones, the vitrificable ones (§ 29.) and the calcareous (§ 30.) are of this Kind; and among thoſe that are not affected by Fire (§ 31.) the chalky, and other ſoft, light, brittle Stones.

338. But when Stones containing an Ore in them, cannot be ſeparated from it by the above-mentioned (§ 337.) Helps, they are called indecantable, (in German 𝔘𝔫𝔰𝔠𝔥𝔦𝔢𝔡𝔦𝔤𝔢.) Such are light brittle *Ores*, that contain a great Quantity of Sulphur, and are interſperſed with the minuteſt Maſſes of the largeſt Surface of the Particles of the Matrix, or incloſed in a ponderous, hard Matrix, eſpecially of that kind that cannot be affected by Fire (§ 31), and which neither Fire nor Water can ſplit.

339. Finally, if there is in the Body of the Ore itſelf any thing intangled, or only adhering to its Outſide, that will cauſe the Metal contained in it to vaniſh into a Vapour, or turn into *Scoria* with itſelf, while the Ore is expoſed to the Fire, then ſuch an Ore is ſaid to be hungry, *minera rapax*. The Cauſes of this are commonly Arſenick, Antimony, and thoſe Minerals out of which Zink is produced.

340. The three Differences hitherto explained (§ 334—339.) muſt always be chiefly regarded, in the diſtinguiſhing of all kinds of Ores: Therefore unleſs you may be certain of them by outward Signs,

you muſt always do your utmoſt to find them out by other Experiments.

341. As Metals and Semi-Metals are ſpecifically the moſt ponderous of Mineral; and the Sulphur and Arſenick, with which the former make up Ores, are none of the lighteſt; it is ſelf-evident, that pure ſolid Ores diſtinguiſh themſelves from the other compound unmetallick Minerals, by their great Weight; only a few Pyrites very ſulphureous (§ 316.) excepted. I ſay pure ſolid Ores: for when theſe are diſperſed here and there, in ſmall Quantities, among large Maſſes of Stones and Earths, they can never be diſtinguiſhed by their Weight.

Of IRON, *and its* ORES.

342. As *Iron* is mixt with all Ores, is preſent almoſt every where, perfectly known, and manifeſting itſelf eaſily, wherever it lies hidden, it deſerves to be placed here at the Head of the reſt.

343. Pure native Iron, if there is any to be found in the mineral Kingdom, is indeed of the utmoſt Scarcity. They take for Iron of this Kind, ſmall octoëdral Stones, as likewiſe Cubes that are alone, or grown together among themſelves many different Ways, having a Form like that of Pyrites of the marchaſite Kind (§ 316), having ſometimes Fibres like Wood; of a yellow, ruſty, brown, dark Colour, very rich in Iron indeed, but yet having, under the Hammer, neither the Ductility of common Iron, nor the Hardneſs of *Steel:* For which Reaſon, they are to be reputed rather Ores very rich in Iron, than pure native Iron.

344. But the Ore of common Iron has no certain Form; being altogether irregular, moſt commonly of a ruſty Colour, having but a middling ſpecifick Gravity among Ores. It is eaſy to extract good Iron out of it. Its Brittleneſs, Hardneſs, and Weight, are ſometimes greater, ſometimes leſs; and the red Colour,

lour, ſometimes deep, ſometimes light, ſhews how much Iron it contains in it.

345. There is alſo an Ore, which is very ponderous, and of a red bluiſh Colour, when broken, and which reſiſts the Hammer by its Hardneſs. It is very rich in the beſt kind of Iron, and commonly yields in the firſt Fuſion, from ſixty to eighty Pounds weight of Iron, in the Center, or an hundred Weight.

346. There is a ſingular Species of Iron-Ore, which has the Figure of Spaad (§ 30, 1): it is of a pale yellowiſh Colour, though not uncommonly grey, and even ſometimes of a half tranſparent White; it yields in the Fuſion about thirty hundredth Parts of the beſt Iron, though the outward Sight of it affords no probable Sign of it whatever.

347. The yellow Pyrites (§ 316.) has indeed been referred to the ſulphureous Minerals; but the Proportions of Iron and Sulphur being ſo inconſtant in it, that it is ſometimes the latter, ſometimes the former which predominates in it, it may alſo be properly numbered among Ores: though, it is hardly ever expoſed to the Fire, to have Iron fetched out of it, becauſe there are Ores more abundant in this kind of Metal.

348. If you compare the Iron-Ores hitherto (§ 342—347.) deſcribed, with the Ores of other Metals, they are indeed refractory: but thoſe which are to be called the moſt fuſible (§ 334.) among Iron-Ores, are thoſe that contain but little Sulphur, or ſulphureous Acid in them; which is betrayed by the Smell that ſtrikes the Noſtrils, while theſe Ores are made red hot.

349. The Hæmatites (called in German Blutſtein, Glaſkopf, and in Engliſh *Blood ſtone*), is of a more refractory Nature in the Fire. As it is gibboſe and arched in part, and partly angular and rectilineal, conſiſting of Planes directed towards one Point, on this Account it looks like an irregular Pyramid: which will appear much more ſo, if you break it. The Outſide of it is pretty well poliſhed, when the

Ruſt has been firſt wiped off; but the Inſide is compoſed of convergent Striæ like the Amianth. If you break it in a tranſverſe Direction to its Striæ, it is like the breaking of Steel that is not tempered very hard. It is of a dark red Colour, very heavy and hard. Moreover, it is almoſt the pureſt Iron-Ore, and mixt with a very ſmall Quantity of Arſenick *. But it is rendered refractory, by a kind of Earth not to be affected by Fire, which may happen to be concealed in it. On this Account, the white Regulus of Iron, which is brittle, and very difficult to be rendered malleable, requires the greateſt Fire to be melted.

350. *Smiris* (in German **Schmergel**, in Engliſh *Emery*, and in Dutch **Amarill**,) is the hardeſt of all the Iron-Ores that are known: it is a little leſs ponderous than the Blood-ſtone, very refractory, of a brown Colour, and really contains Iron; though the extracting of it is not worth the Charges: Wherefore Workmen pound it only, and uſe it to poliſh Steel: it is likewiſe employed to cut Glaſs, and poliſh certain Jewels.

351. *Magneſia* (in German **Brunſtein**, in Engliſh *Mangameſe*) is here and there nicely ſtriated with convergent Striæ: it has no certain Figure, and is of a greyiſh black Colour. It is frequently met with in Iron-Mines; and itſelf contains Iron; but the extracting of the Iron out of it by Fire, never anſwers the Charges, it being rapacious, and yielding no other but friable Metal. It is of greater Uſe among thoſe that make cryſtal-Glaſſes, to take away their green or blue Colour, and to abate their too great Tranſparency.

352. There is a kind of Ore not unlike the foregoing (§ 351), which is of a dark grey Colour, ſhining, ſtriated, and alſo containing Iron, but rapaci-

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* Some Sorts of Hæmatites are ſo very rich in Iron, as to be capable of taking ſo fine a poliſh, as to look like burniſhed Steel, particularly a kind called in Italian *Pistra di Nicola.*

ous, and arſenical: for which Reaſon Metallurgiſts do not extract Iron out of it. It is called in German **Eiſenman, Eiſenglimmer**.

353. There is alſo, but eſpecially in Tin-Mines, a kind of ſtriated Ore, made of Filaments of an irregular Texture, and dark coloured, which, when ſcraped, appears ſometimes of a dark red Colour: it is ponderous enough, and likewiſe contains Iron, but it is at the ſame Time very arſenical; on which Account it is always rejected by Metallurgiſts, as being very prejudicial. The Germans call it **Woolfram.**

Scholion. *The Iron-Ores hitherto* (§ 342--353.) *mentioned, as well as all the other Minerals, are called by different Names, which often ſignify but one and the ſame: and as theſe Names vary in all Places, it is impoſſible, and would even be ſuperfluous, here to mention them all: Eſpecially, becauſe many of the ſaid Names are derived from a Compariſon very often defective, of Figures obſerved hardly once or twice, and of courſe very little eſſential. Therefore you will ſee Pepper, Beans, Peas, Confections of Coriander, Cinnamon, Iron,* &c. *reckoned among Iron-Ores, by Authors curious of trifling Matters.*

354. We ſhall alſo claſs here the Oker of Iron, which ſeems to have its Origin from comminuted Iron-Ore, and eſpecially from the yellow Pyrites deſtroyed. It looks like a kind of fattiſh Earth, it has the Colour of Ruſt, which nevertheleſs is rendered ſometimes yellow, ſometimes darker, by a Mixture of other Earths; this occaſions a Variety, in the Weight of this Oker. It is found both in dry and marſhy Places; it forms here and there whole Veins and Strata, and is likewiſe found, though impure, in almoſt every Place, as in Marls, Clays, and Boles. This Oker is ſo very rich of Iron in ſeveral Parts, that it anſwers equally the Charges of extracting, as the beſt Iron-Ore.

355. Red-Lead, or red-Chalk, ſeems to be deſcended from this kind (§ 354.) of Oker, and to have been hardened by a Mixture of Bole and Clay. It is

of the reddiſh Colour, of a middling Weight, tender, ſo that it may be eaſily ſcraped and figured with a Knife; it has a ſoapy Feeling: when expoſed to a great Fire, it grows very hard, and aſſumes a darker and ſhining Colour; it contains much Iron in it.

356. It has been obſerved, that whenever Sand is of a blackiſh Die, it has Iron or Lead in it. But its great Weight ſhews, that it contains a conſiderable Quantity of Metal.

357. We might very well range in the ſame Claſs, all native vitriolic Minerals; ſuch as the ſtalactic Vitriol, and the Stones uſed for the making of Ink: for they either are purely of Iron, or at leaſt, conſiſt in great Part of Iron corroded by the Acid of Sulphur. We might alſo place here the *Lapis Calaminaris*, and many other Minerals; but as the ſeveral Metals drawn out of them, require each a ſpecial Management, we ſhall treat of them more at large hereafter.

358. The Mineral called *Flos ferri*, or Bloſſoms of Iron, is nothing but a Stalactites (§ 30, 3), reſembling a Germination like that of Corol. It is called *Ferri Flos*, becauſe it has now and then been found about a calcareous Iron-Ore: Nor does it ſeem to deſerve this Name, upon any other Account.

359. There is found, in ſeveral Iron-Mines, eſpecially thoſe of *Sweden* and *Norway* *, an Ore called the *Magnet* or *Load-ſtone*: which is a black ponderous Stone, not very hard, when pure. It is often intermixt with Flints and Spaad, in which Caſe it is leſs good. You may ſee the wonderful Properties of this Stone, mentioned in the Writings of Naturaliſts. But we ſhall here chiefly treat of that of its Qualities, by which we may find out the occult Preſence of Iron. The Load-ſtone attracts Iron at a great Diſtance, and holds it ſtrongly to itſelf, unleſs an exceſſive Weight, or ſome other Obſtacles hinder the Effect; nor is there any other Body but Iron, that is attracted in

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* And in many Parts of *England*, whereof ſeveral Specimens are to be ſeen in the *Muſeum* of the *Royal Society*.

this Manner by the Load-ſtone; as has been evidenced by a Multitude of Experiments made with it. Now, whether any Body contains Iron in it or no, we find with the Load-ſtone in the following Manner. You firſt reduce the Body to be tried into a fine Powder: which muſt be done in a Braſs-Mortar, eſpecially if the ſaid Body be hard, but never in an Iron one: then you put this Powder into a Crucible, having a Cover to it, and well luted, either without any Addition, or, for greater Security, with a ſmall Quantity of Tallow; and make it red hot for about an Hour in a ſtrong Fire. When it is grown cold, if you extend it upon a ſmooth Paper, bring the Load-ſtone itſelf, or its armed Iron-Poles near to it *. If there are any Iron-Particles in this Powder, they will apply themſelves either to the Load-ſtone itſelf, or to its armed Poles, and hang on it like Beards. When you ſee this, wipe off the adhering Particles, that they may fall aſunder, and then put the Load-ſtone again into the Powder, and move it up and down. By the ſame Thing often repeated, you will at laſt have taken away all the Iron, leaving only the Particles that partake not of Iron.

360. But there are very few Iron-Ores attracted by the Load-ſtone, before they have been made red hot in the foregoing (§ 359.) Manner, not excepting even the Blood-ſtone (§ 349), though ever ſo rich of Iron. Which is the more wonderful, becauſe Iron, though adulterated with other Metals, or Semi-metals, and even mixt with Arſenick, is not thereby rendered altogether unapt to be attracted by the Load-ſtone. *Antimony* is the only metallick Body, that can hinder this Action. *Sulphur* can hardly hinder it, becauſe the Blood-ſtone juſt mentioned, red Chalk, Oker, and the more ſolid Iron-Ores, that are not of the Pyrite kind, loſe but very little, and ſome of

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* If you have not a Load-ſtone at hand, the Blade of a Knife or any other poliſhed Piece of Iron which hath been touched on a Load-ſtone, will have the ſame Effect, but not ſo ſtrongly.

them nothing at all of their Weight, by being burnt in the Fire. Nor does it ſeem probable, that there is any Antimony hidden in all theſe Minerals. But what makes this Matter more obſcure is, that the Blood-ſtone, red Chalk, and ſome other Iron-Ores, without adding any phlogiſtical Matter to them, are rendered capable of yielding to the magnetick Virtue, by being only made red hot in a Veſſel well cloſed; while, on the contrary, the other Bodies, when made red hot, require the Addition of a more fixt Phlogiſton, without which the Load-ſtone would have either no Iron at all, or a much leſs Quantity of it to attract. On this Account, there have been two Opinions eſpouſed by Authors. Some are of Opinion, that mineral Sulphur, and the Acids adhering to Iron, hinder it from being attracted by the Load-ſtone; and that conſequently they muſt either be diſſipated or changed, to reſtore to Iron its magnetick Virtue. But it is repugnant to their being diſſipated, that ſome Ores made red hot in cloſe Veſſels, without any Addition, and loſing not the leaſt Part of their Weight thereby, yet become capable of being attracted by the Load-ſtone; as it is repugnant to their being changed, that mineral Sulphur, and its Acid, are never altered in cloſe Veſſels, by Fire alone, without any Addition; and that on the contrary the ſulphureous Acid, with an Addition of a true Phlogiſton, regenerates the true mineral Sulphur, which nevertheleſs is ſuppoſed to reſiſt the Action of the Load-ſtone. Now the Phlogiſton made red hot with Iron Ores, is very proper to revive the Attractibility: Nor can this be any way obtained, when the Uſtulation is made with pure alkaline Subſtances, that really change the Acid of Sulphur. The other Opinion, taken from the Deciſions of the illuſtrious Mr. *Stahl*, is, that Iron is ingendered by a Phlogiſton, mixt with a ferruginous Earth, by Means of Uſtulation: which will appear the more probable, if you attend to the following Conſiderations. 1. The Ores and Earths which being made red hot without any Addition, are not attracted by the Load-ſtone, if you melt them either alone without adding any Phlogiſton or only by Means of an unphlogiſtical Flux, in the ſtrongeſt Fire, will turn into a metallick Glaſs, not into a *Regulus*. 2. With this Glaſs, and by Means of a due Addition of Phlogiſton, you will produce the moſt perfect Iron in the Fire. 3. Iron deſtroyed by Acids, Fire, or any other Means, or only turned into Ruſt, is not attracted by the Load-ſtone: and then when it is melted by a ſtrong Fire, without adding Phlogiſton to it, the ſame Thing happens, that was mentioned (N° 1). Whence it is plain, that by an inflammable Oil, Iron is produced from what was no Iron. See (§ 90—95). Nor is it a Contradiction to this Opinion, that ſome Ores receive a magnetick Virtue, though made red hot without any thing added to them. For nothing hinders the Phlogiſton, which is neceſſary to conſtitute the metallick Nature, from being already preſent in the Ore, though it be not as much united with the fine Part that conſtitutes the Iron, as is required to give it its metallick Form: ſo that it is neceſſary previouſly to unite it thereto by the Action of a ſtrong Fire; which is always requiſite in all Reductions.

Of COPPER, *and its* ORES.

361. Native Copper, that is, Copper in its metallick Form, is found much more frequently and more perfect than Iron. However, it is yet ſomewhat leſs malleable than Copper well forged.

362. It muſt be obſerved of Copper-Ores in general, that none of them diſtinguiſhes itſelf by any certain Figure, but that they are almoſt all of them irregular. But the fineſt Colours of any Kind, red and the diaphanous Colours excepted, moſt commonly betray the Preſence of Copper, when they are to be ſeen in any Ore. For this Reaſon, there is hardly any Copper-Ore, that is not mixt with Iron in greater Quantity, than the Ores of other Metals commonly are. Nevertheleſs, there is a much leſs Quantity of it

[illegible] than in others. But we reckon [illegible] Iron in them, to be naturally [illegible] Such are,

[illegible] Copper-Ore, in German Kupfer [illegible]. [illegible] -Colour, [illegible] a red [illegible] Colour is commonly interrupted [illegible] Spar and grey Veins. It [illegible] a middle Hardness. One [illegible] from fifty to [illegible] Weight of Copper.

[illegible] Copper-Ore, is of a most beautiful [illegible] very heavy, broken, [illegible] Copper-Ores it is [illegible] Iron, Arsenick, and Sulphur, [illegible] in the Ustulation [illegible] Quantity of excellent Copper, [illegible] very good Ease.

[illegible] Copper-Ore is like green Cryſtals, [illegible] almost like a Germ[illegible] this Ore has the Pro[illegible].

[illegible] Cæruleum Montanum, in German [illegible], and the green ones, [illegible] in German [illegible] the Name of Copper-[illegible], yield a good Deal of very good Copper, when they are pure, which appears from the Colour and Weight of them. But the lighter ones are mixt with [illegible] Earths: those that are yellow contain Iron-Ochre: on which Account they are more difficult to be melted, and yield less Copper, and of an inferior Goodneſs. This Mountain-Blue, and the green are carried here and there by Waters, and apply themſelves to the Outside of Lumps, like a Paint.

[illegible]. The white Copper Ore, in German Weiſs-Ertz, [illegible] hitherto found only in one ſingle Mine of

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[illegible] of this Copper-Ore germinates like the Bloſſoms of Iron [illegible] like white Coral tinged of a bluiſh green Colour. [illegible] properly be called *Flores Cupri*, or Bloſſoms of Copper.

Miſnia; the grey one, in German **Fahl-Ertz**; and the dark aſh-coloured, in German **Fahl Kupfer-Ertz**, deſcribed by *Henckel*, in *Pyritol.* Pag. 195, 197, are ſolid, ponderous, and rendered white by Arſenick. The firſt Species is diſtinguiſhed from the white Pyrites (§ 323), by a Colour ſomewhat yellowiſh, but the others are diſtinguiſhed from it, by a much darker Colour: They at the ſame Time are all diſtinguiſhed by their greater Weight, and breaking ſmoother: which is more exactly perceived, when you compare together the native Specimens of the Bodies to be diſcerned.

368. There is alſo a Copper-Ore, called by ſome Vitrean, and poſſibly not very different from that above deſcribed (§ 363), except in the Quantity of Iron it contains: on which Account it is harder than the former, and of a darker Colour: it melts with greater Difficulty than the foregoing ones, and is nevertheleſs very rich in Copper. We muſt likewiſe rank in the ſame Claſs, that Kind of dark red Ore which is almoſt of a Liver-Colour, and which is not eaſily diſcerned by the bare Sight, from an Iron-Ore of the ſame Colour.

369. The merely ſulphureous Copper-Pyrites is of a yellow Gold Colour, with a light Tincture of green, both within and without; if you break it, the Inſide has a kind of granulated Surface; it is eaſily beat into Powder, and contains Sulphur and Copper in many different Proportions, whence its ſpecifick Weight varies likewiſe very much. But if it is very rich in Copper, and at the ſame Time mixt with any Quantity of Arſenick, its Gold-Colour becomes yellowiſh, and when you break it, the Surfaces are ſmoother, neater, and more even. In this Caſe, it is called in German **Kupfer-glantz**. Very often, it is of the brighteſt Green and Blue, both at the Outſide, and between the Chinks: Nevertheleſs, if you break it, and thus diſplay a new Surface, theſe Colours ſeem not to penetrate through the whole Subſtance of it. But when the Copper Pyrites are mixt with a conſiderable

derable Quantity of Arſenick, they then look pale, like the ſulphureous Copper (§ 316.) Pyrites; and even are whiter than this, according as the Quantity of the Arſenick is greater. Nevertheleſs, they, even in this Caſe, are diſtinguiſhed from the Iron-Pyrites, becauſe they are more ponderous, and give not Sparkles ſo eaſily, if even they give any, when ſtruck with a Steel: which every Iron-Pyrites (§ 316, 323), and any ſolid Iron-Ore will do.

370. The Reaſons why the Copper-Ores above-mentioned (§ 363—369 are rendered refractory, and even entirely unfuſible, are explained (§ 336).

371. The yellow ſulphureous Iron-Pyrites (§ 316.) belongs likewiſe to this Claſs, though improperly. For it often contains in it a Quantity of Copper, not to be deſpiſed, but it is looked upon as improper to Copper, and as very refractory, on account of its great Quantity of Iron. In the mean Time you find out whether it contains Copper; 1. From its not being of a globular Figure: for it is evident from the Obſervations of *Henckel*, that globular Pyrites are altogether deſtitute of Copper. 2. From its unuſual Yellowneſs ſpreading through the whole Subſtance of it.

Coroll. From the above-mentioned (§ 369, 371.) Particulars, we may eaſily deduce ſome Rules, whereby we ſhall be able poſitively to affirm, that a Pyrites contains Copper in it. For Inſtance, let this be a Rule: *The gold greeniſh Colour of a Pyrites is a Sign of its containing a great Quantity of Copper:* which is confirmed by Experience. But you cannot by any Means invert this Rule thus; *If a Pyrites contains a great Quantity of Copper, it is of a gold greeniſh Colour:* becauſe when Arſenick is mixt with a Pyrites, even one that is very rich of Copper, it makes it entirely look pale (§ 369). The ſame may be ſaid of every ſuch Rule.

371. The Ore which has been mentioned (§ 328), under the Title of *Kupfer-nickel*, when we treated of Arſenick and arſenical Minerals, may have a Place

here, but only as being improper. It contains a Quantity of Copper not inconſiderable, but it is neglected, becauſe the Cobalt, wherewith it is incumbered, renders it almoſt untractable. In the mean Time you are to obſerve, that what renders Ores intractable, is not the Arſenick itſelf, but a kind of Earth, which is always united to the proper Minerals of Arſenick, eſpecially to Cobalt (§ 325), which reſiſts Fuſion very much, and by Means of the Arſenick that is fixt in it, adheres with great Tenacity to Metals, eſpecially to Copper and Iron.

Of LEAD *and its Ores.*

372. There are very few Inſtances, of native Lead's exiſting naturally pure and malleable, among other Metals *.

373. *Galæna teſſellata*, or the Cubic Dice-Lead Ore, called in Germany **Bley-glantz**, is an Ore very rich of Lead, conſiſting of a Quantity of ſmall equilateral Cubes, or of oblong Parallelopipeds. But theſe Cubes are, as it were, compoſed of very thin, well poliſhed Lamina's, that ſhine very bright, and are of a blackiſh blue Colour. However, this Ore is very ponderous, ſoft, and brittle; it is more fuſible than a great many other Ores, though it requires a much greater Fire to be melted, than Lead itſelf: the Cauſe of which is the Abundance of Sulphur, that lies hidden in the Lead-Ore, and conſtitutes almoſt one quarter Part of it. In a Fuſion well managed, one hundred Pounds weight of pure and ſolid Lead-Ore, will yield from 65 to 70 Pounds weight of Lead.

374. If the Lead-Ore (§ 373.) conſiſts of ſmall, thin, oblong Cubes; when broken, it appears finely ſtriated, and is called in *German* **Klar Spieſſiger Bley-glantz**.

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* Some pure native malleable Lead hath been found at this Day in *New England*. What is commonly taken for native Lead, is really a very rich, ſomewhat malleable Silver-Ore of a lead-Colour. See (§ 385).

ſeen very ſeldom. Nevertheleſs, *Mattheſius* ſays, that the Thing has happened ſometimes.

379. The moſt rich Tin-Ore is of a black or dark Colour of a polyhedral, but altogether irregular Figure; having its Surface very gloſſy. This ſurpaſſes almoſt all the Ores of the other Metals, in its ſpecifick Gravity †: which ſeems to be the more wonderful, becauſe Tin is the lighteſt of all Metals. But as Arſenick is exhaled almoſt pure out of this Tin-Ore in the roaſting, and as the Part of it that remains after the roaſting (if you conſider how much of the Tin is deſtroyed during the whole Time of the Reduction) is to be reckoned purely metallick; it is eaſy enough to gueſs at the Cauſe of this Gravity. As for the reſt, it is of a middle Hardneſs, and, with regard to the Tin itſelf, is very refractory: for it ſuſtains a quick Fire, without either melting or growing clammy; and if you expoſe it to a ſudden Heat, it neither burſts violently nor crackles, except when an Experiment is made upon large Lumps, among which other Ores, or ſome Stones, eſpecially of the Quartz-Kind are intermixed. This Ore is called in German **Zinn-Graupen**, in Engliſh *Tin-Grains*.

380. The moſt common Tin-Ore, called in German **Zwitter**, is of a dark yellowiſh ruſty Colour: ſo that on this Account it cannot, by the bare Sight, be eaſily diſtinguiſhed from the Iron-Ore; eſpecially as it contains itſelf Iron. The Figure of it is irregular, and agrees in every Reſpect with that of the foregoing (§ 379); for which Reaſon it ſeems to be another of the ſame Kind, and to differ from it only by its Degree of Purity.

381. We may, after having explained (§ 379.) what happens to the Tin-Ore in the Fire, find out by an Experiment made *ex tempore* in the following Manner, whether there is any Quantity of this Ore contained in any Lump offered for Trial, and about

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† Inſomuch as ſometimes to have a greater ſpecifick Gravity than a Piece of Tin of the ſame Size melted from it.

what Part of it lies hidden therein. Pound the Lump into a Powder not very fine, and waſh off from it with Water the light terreſtrial Filth that is in it. Then upon a flat, not over broad Shovel, made quite white hot, and having not a high Border, ſprinkle your Ore, after having pounded, waſhed, and dried it, and divide it in ſuch Manner, that it may not be heaped up in any Place, but quite ſpread: This muſt be done, that all the ſprinkled ſmall Parcels of the Ore may grow red hot quick enough, and that the ſmall Stones which may happen to be under or intermixed with them, may not, in their flying aſunder, carry a conſiderable Quantity of the Ore away with them. Thus the ſmall Stones will be diſſipated with a gentle Noiſe, as alſo the heavy intermixed Ores of other Metals that are leſs well waſhed; becauſe there is hardly any of theſe, that can bear a ſudden Heat: There will remain the Tin-Ore, become of a reddiſh Colour, and covered with a kind of of grey arſenical Flowers.

381. The Garnate is reckoned among precious Stones: its of an unſettled Figure, though moſt commonly dodecaëdral †, regular enough, not rare, half tranſparent, and having its Name from the Flowers of Pomegranates of which it has the Colour. This now and then contains Tin; ſo that on this Account it deſerves to be reckoned among the Ores of this Metal. Nevertheleſs, all kinds of Garnates ought not to be referred to this Claſs. For they ſell, under the ſame Name, Stones that have indeed the ſame Colour, but are more tranſparent, vitreſcent and are rather of the Nature (§ 29, 4.) of Flints.

383. The Tin-Ores mentioned (379, 380.) which are rendered refractory by the Stones and Earths mixt with them, may among the other Ores be very well improved by waſhing and roaſting, on account of their conſiderable Weight, and Conſtancy in a middle Fire. But they can never be totally freed

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† Or compoſed of twelve Sides.

from the Iron-Ore, eſpecially that kind of rapacious Iron-Ore, that was mentioned (§ 353), which is very often intermixed with Tin-Ore. For this Reaſon, the Tin melted out of theſe Ores, is leſs perfect and true than that yielded by a pure Ore. For Iron mixt with Tin, turns into a hard untractable (§ 59.) *Regulus*, that can never be ſeparated with any Benefit. The Copper-Ore, likewiſe, is ſometimes found mixt with Tin-Ores, under the Form of Oker, or of Pyrites: it renders the Tin extremely brittle, when it melts together with it in any conſiderable Quantity: But this Ore is more eaſy to be fetched out by waſhing and roaſting, than the Iron-Ore.

Coroll. From what has been juſt (§ 383.) ſaid, you may eaſily gueſs, what kind of Tin any Ore will produce; and why Engliſh Tin is the beſt of all. For its Ore is, of all Tin-Ores, that which is leſs defiled with Iron.

Of SILVER, *and its Ores.*

384. Pure ductile Silver, not defiled by Sulphur or Arſenick, is found naturally and much more frequently than the foregoing Metals, in ſmall Maſſes of many different Figures, eſpecially under the Form of Filaments and Scales, in many various Stones, and Earths, and in ſeveral Kinds of Sand, that are even expoſed on the Surface of the Earth *.

385. The vitrean Silver-Ore, is of an irregular and altogether unſettled Figure. It is very ponderous, eaſy to be flatted with the Hammer, and to be cleft, not much harder than Lead, and much of the ſame Colour; it melts preſently, and ſoon grows red hot †. It conſiſts of Sulphur and of pure Silver: which the Regeneration of it (§ 140.) and the Che-

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* The moſt beautiful is in thin Plates with various Furrows on them, ſo as to make the Plates reſemble real woven Silver-Lace.

† This is often miſtaken for native Lead. See the Note to (§ 372.)

mical Analyſis ſhew. It contains above three quarter Parts of Silver.

386. The horny Silver-Ore is half tranſparent, it is of a deeper or lighter yellow or brown Colour, according as it conſiſts of larger or ſmaller Lumps, it looks like Roſin, and has an irregular Figure on the Outſide; but when examined cloſely within, it appears to conſiſt of very thin Plates. Nor is it very ponderous, nor hard, but eaſy to be ground: when brought ſuddenly to the Fire, it crackles, burſts at a great Diſtance, as moſt Ores do, and in this Caſe exhales a ſulphureous Smell, and ſometimes burns lightly, and finally caſts forth ſomething arſenical, but in a very ſmall Quantity. On this Account, it ſeems to differ from the foregoing (§ 385), at leaſt with regard to the Quantity of Sulphur. For it hardly contains two thirds of Silver in it.

387. The red Silver-Ore, is of a ſcarlet Colour, ſometimes lighter, ſometimes deeper [*]; in the firſt Caſe, it is tranſparent like the arſenical Ruby; and in the ſecond Caſe, it is of a deeper Dye. It varies its Figure, though it is often of the cryſtalline priſmatical Form; it is heavier than the foregoing (§ 386.) horny Silver-Ore; but it burſts, when brought near a Candle, or a mild Fire, and the remaining Part of it melts immediately, before it grows red hot; and then it emits the diſagreeable Smell of Arſenick, together with a thick viſible Smoak: It has ſomething ſulphureous in it, which is evidenced by its burning violently and by the Smell of the nitrous Acid, which riſes from it when you ſprinkle upon it Nitre put in Fuſion, and made red hot: which Phænomena are the Effects neither of the Arſenick, nor of the Silver; ſo that the ſcarlet Colour of this Ore ſeems to proceed from this Cauſe (§ 148.) You may ſometimes extract with the Load-ſtone

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[*] Much reſembling a Garnate, and hath by its outward Appearance been miſtaken for tranſparent Cinnabar. See the Note (§ 402.)

(§ 359.) out of the *Caput Mortuum* of this Ore, ſome Iron remaining after the Sublimation made in cloſe Veſſels; though you uſe the choiceſt Bits of the Ore for this Experiment. However, it has in it the ſame Quantity of Silver, as the horny Ore above-mentioned (§ 386.)

388. The white Silver-Ore, of a light grey Colour, of an irregular Figure, pretty ponderous, and very brittle, has at the ſame Time ſome Copper in it; nay, it even contains moſt commonly more Copper, than Silver: ſo that it differs from the white Copper-Ore (§ 367.) only on account of the Quantity of Silver it contains. It is heavier than the two foregoing (§ 386, 387.) yielding however leſs Silver than they. The Lead-Ore, eſpecially the granulated Ore (§ 373), which is of a lighter Colour, is ſold for it. See *Henckel's Pyritol.* Pag. 170, 195.

389. We have not hitherto known any beſides theſe four (§ 385—388.) Silver-Ores, though many others are looked upon by ſome, as ſuch: However, the Thing being well examined, they either are improper to Silver, or prove to be compoſed of the already mentioned proper Silver-Ores; that is, ſometimes of them all, and ſometimes of only ſome of them, mixt together in many different Proportions. And this Mixture is ſometimes ſo very ſubtle, that it can hardly be perceived with a Microſcope. And indeed among the Iron, Copper, Lead, and Tin-Ores, already explained (§ 342—382), you will ſometimes find ſome, that will yield no inconſiderable Quantity of Silver; but as theſe contain more of the other Metals, they, on this Account, muſt be called improper Silver-Ores, when they have any Silver intermixed with their Subſtance (§ 311.) or accidental Silver-Ores, when there is only ſome Silver adhering to their Outſide (§ 311.)

390. The white and grey Copper-Ores (§ 367) may be called improper Silver-Ores, as they are always impregnated with Silver. But the other Copper-Ores, though they moſt commonly contain Silver,

ſo that there is ſometimes a great Quantity of Silver got out of them; nevertheleſs, cannot always be referred to this Claſs, unleſs you have, in ſome ſpecial Caſe, found out by Experiments, that they contain Silver in them: for we have not hitherto found out any certain Characteriſticks, and outward Signs, from which we might decide, whether any Ores contain Silver in them, or no. And if any ſuch Characters have been found out, they uſually are regarded only with relation to the Mine that yields the ſaid determined Ores: ſo that People that do not uſe the neceſſary Cautions, are often deceived in making an univerſal Application of ſuch external Signs.

391. It is the ſame with the Lead-Ores: for the more nicely ſtriated, among theſe, the granulated Ores (§ 374), and thoſe that have a changeable Brightneſs, are referred to the Claſs of the Ores that contain Silver: becauſe, there is ſometimes ſo much Silver in them, that it is of greater Price than the Lead thereto adhering. Some look upon them, and not without Foundation, as real Silver-Ores. But this Rule ſuffers a great many Exceptions; while, on the contrary, the Lead-Ore conſiſting of large cubical Parts, which is generally thought to contain Silver, is of equal Value to that of the foregoing, with regard to the Silver.

392. Finally, it is proper to forewarn every one, not to be overhaſty in thinking, that there is generally Silver contained in the Ores of Copper, Lead, Iron, *&c.* becauſe Silver may be extracted out of the Lump, in which this kind of Ore predominates, or out of the Metal that has been melted from it: nay, before you make your Experiment, and determine any thing, you muſt previouſly and with great Care chuſe an Ore, perfectly pure, looking homogeneous, and altogether free within and without from any Mixture of Stones, that might perhaps conceal ſome Silver-Ores (§ 384—388). For unleſs you take ſuch an Ore for your Experiment, you will never be able to conclude with certainty, from any Silver fetched

out of it, that it is fruitful in this Metal ; as there are very few Ores, that are not ſometimes contiguous to Silver-Ores. But if ſuch a Concretion has been made by minute Maſſes, you cannot eaſily perceive at firſt Sight, whether it is proper to the Ore, or only accidental. Hence the Reaſon may be underſtood, why *Regulus's* precipitated ſeparately and at different Times, out of impure Bits of Ore, when tried, do not yield at every Time the ſame Quantity of Silver, in proportion to that of the Metal, though no Errors are committed in the Operation ; which never happens, when the Ore is well beaten and mixt before, or when you uſe it perfectly pure.

393. The pure (§ 384—388.) proper Ores of Silver, either thoſe that are incorporated with ſome pure Copper or Lead-Ores, or thoſe that are only intermixed with them, are of themſelves fuſible. Now, what Ores are refractory and not fuſible may be underſtood from what was ſaid before (§ 334.), as it holds equally true of all kinds of Ores. But the Tin-Ore requires here a particular Conſideration : for, in the Fire, it is refractory neither alone, nor joined to other Ores : nay, Tin may be very eaſily mixt with Silver, but above all with Lead (§ 41 and 57): However, it ſometimes happens, that, as ſoon as you increaſe the Fire, ſo as that the Lead may grow red, the Tin ſeparates from it (§ 41.) in form of Calx ; which Calx is altogether indiſſoluble by Lead, and with great Difficulty diſſolved by the Glaſs of it, and takes away a great Quantity of the Silver, when this has been mixt before with Tin. But Silver is, by Lead, waſhed off with a ſtrong Fire, from all heterogeneous Metal, Gold excepted. Whence it is plain, that Silver and its Ore, when Tin or its Ore is mixt to it, muſt be looked upon as refractory, and for what Reaſon.

Of GOLD, *and its Ores.*

394. *Gold*, whoſe Characteriſticks are very (§ 6.) remarkable, is free from Sulphur and Arſenick; of all other Metals it is moſt frequently found native; has no certain diſtinctive Figure, and conſiſts only of ſmall irregular Maſſes. It will not be improper here to mention at leaſt its principal *Matrix's*.

395. There is a *Flint*, or *white Quartz* (§ 29. N° 4.) in which Gold commonly lies hidden in very ſolid and large Maſſes. It is concealed likewiſe, but more ſeldom, and in leſs Quantity, in that yellow and blue kind of Stone, which ſome call the *Lapis corneus*.

396. That kind of blue Stone, which may be cleft, and, on Account of its Colour, is called *Lapis Lazureus*[†], often moſt elegantly ſparkling with very ſmall ſpeckles of Gold: The Gold, nevertheleſs, is leſs ſolid in this Stone, than in the foregoing ones (§ 395.)

397. There is hardly any *Gravel* in the Nature of Things, that does not contain Gold in it: as do likewiſe ſeveral fat ſlimy *Earths*: But they are ſeldom rich enough in Gold to pay the Charges of extracting it therefrom by waſhing and Amalgamation. But that kind of Gravel which is found in the Channels of Torrents and Rivers, or near them, eſpecially where the Canal makes many Windings, is commonly richer in Gold than all the reſt[*].

398. This *native Gold* (§ 394.) is very ſeldom found altogether pure, but is commonly mixed with Silver: Nevertheleſs, that which is found in the Gravel and Earths mentioned (§ 397), is rather more mixt with Silver than that which is wedged into a ſolid *Matrix* (§ 395, 396.)

[†] *Lapis Lazuli*.

[*] Such Gold Duſt is to be found in ſmall Quantities, in ſome of the Rivers of *Scotland*. At the Coronation of King *Charles* I. ſome Medals were made of this Gold, with this Legend round the Edge, *Ex auro, ut in Scotia reperitur*. One of which is to be ſeen in that admirable Collection of Sir *Hans Sloane* Bart. *&c.* and many of the Country People have gathered enough to make Rings of.

399. No *Ore*, that I know, hath been hitherto found, in which Gold conſtituted the greateſt metallick Part; ſo that I cannot mention any Ore (§ 311.) proper to Gold. The ſame is teſtified by the Authors that are moſt ſkilful * in the Knowledge and Trial of Minerals. There are indeed ſeveral Ores ſold under that Title; but which, after a ſtrict Examination, are found not to be ſuch; for in thoſe Places where Gold is waſhed out from Gravel and Earths (§ 397.) you often find Tin Ores in Grains, as likewiſe the Garnates mentioned (§ 379—382.) In which Caſe the rapacious Iron-Ore, called in *German* (353.) **Wolfram**, which is commonly joined to theſe, is ſeldom wanting: Nay, it has ſometimes happened, that many People deceived by the red yellowiſh Colour of theſe Ores, looking as if there was Gold in them, have miſtaken them for Golden Ores: Mean while, I never ſaw any Body grow rich by Means of them, or any Gold melted out of them. The ſame thing is to be concluded of the *Golden Marchaſites*; ſo called becauſe they are nothing but ſulphureous *Marchaſites* † (§ 316.)

400. There are no Ores improper to Gold, but Silver Ores: For it is in theſe alone, that Gold penetrated with Sulphur and Arſenick, has diveſted its metallick Form. If Gold is found in other Ores, there is a much greater Quantity of Silver joined to it: So that they rather belong to the Claſs of the Silver Ores; among which they have already been reckoned.

Coroll. As Gold is moſt conſtant and incorruptible in the Fire (§ 6), its moſt ſubtle Particles are eaſily diſtinguiſhed from Particles of the ſame Colour (§ 316):

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* *Laz. Erck. Aula Subterranea*, p. 55. *Georg. Leonhard. Von Lochneyſs*; *Nachricht vom Bergwerk*, p. 125. *J. F. Henckel* Pyritolog. p. 167, 226, 667.

† The *Engliſh* Miners confound the *Marchaſites* and *Pyrites*; and generally call them by the common Name of Mundicks. See *Woodward's* Method of Foſſils.

For the former not only retain their Colour in the Fire, but, if they have been defiled, they even become the more beautiful. Whereas the Colour of the latter changes entirely into a dark Red, and their ſhining Surface becomes duſty; nay, if there is then any golden Particles in them, they are but the more conſpicuous for it.

Of MERCURY, *and its Ore.*

401. *Native*, fluid, *Quickſilver*, called *Virgin Mercury*, moſt commonly lies concealed in an aſh-coloured ſoft Stone, eaſy to be cleft: In which it may be detected by the naked Eye, or by Means of Microſcopes, under the Form of ſmall Drops. It is found in great Quantity eſpecially about *Idria* †, ſo that ſometimes little Drops of it running together out of the *Matrix*, may be gathered in ſmall Veſſels.

402. There is but one ſingle Ore of Mercury known, called *Cinnabar*; of which you will find very good Specimens in every Druggiſt's or Apothecary's Shop, under the Name of native Cinnabar *. It is of the fineſt ſcarlet Colour, and, when broke, appears ſtriated with ſmall parallel Furrows: Beſides, it is very heavy and ſoft, and conſiſts of mere Sulphur and Mercury; in ſuch Manner however, that the Quantity of the Mercury is commonly above ſix Times greater than that of the Sulphur, and that the Beauty of the Colour of the Cinnabar depends on the Abundance of it: As the Regeneration and Chemical *Analyſis* of Cinnabar ſhew. Hence the Reaſon is likewiſe evident, why this Ore is ſo very volatile, in compariſon of other Ores.

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† *Idria* is a Town in the County of *Goritia* and Province of *Carniola*. See Dr. *Brown's* Travels, *Lond.* 1685, Fol. p. 81.

* There is in *London* great Plenty of the fineſt native Cinnabar or Quickſilver Ore to be had, as yearly imported by the *Eaſt-India Company* from *China*; it is of a beautiful red or vermilion Colour, and Semi-tranſparent; reſembling the red Silver-Ore (ſee the Note to § 387) but of a lighter Colour.

403. Mercury, and its Ore, Cinnabar (§ 402.) is more ſeldom found than any Metal; ſo that according to the Calculations of Dr. *Hoffman* †, there is fifty Times more Gold got every Year out of the Mines, than Mercury or its Ore. This indeed is very true, but it ſeems to be no leſs certain, that Mercury and its Ore offer much more frequently than we think, but are not known to us. This will appear probable to any that will conſider, that Metallurgiſts try the Minerals unknown to them, in a ſtrong open Fire only, making with them Scorifications, Coppellations, and various melting Precipitations; and neglect, or perhaps are ignorant of thoſe Operations that are made in cloſe Veſſels; becauſe they hardly ever think of Mercury, except when Quickſilver itſelf, or the ſcarlet Colour of its Ore (§ 402) offers to their Eyes. Beſides, the Colour, Weight, and Figure of Cinnabar (which is nevertheleſs moſt eaſily diſtinguiſhed from other Minerals, when pure) are altered to ſuch a Degree by the other Minerals mixt with them, that can never be detected by the mere outward View, and without making an Experiment.

Coroll. You will indeed find in the Works of Chemiſts, ſeveral Experiments mentioned, by which they ſay that Mercury has been fetched out of Minerals; but all theſe Experiments are here of little Service to us. For, 1. Theſe Minerals are not exactly deſcribed; ſo that they could not be diſtinguiſhed, if they ſhould offer to us: And if they have been called by a Name, the ſame is alſo common to many other Things, or the Signification of it known to none but the Author himſelf. 2. The Particulars neceſſary in the relating of Experiments, have been almoſt entirely omitted.

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† Diſſert. Phyſico-Chemica, de Mercurio & Medicam. ex Mercurio ſelectioribus, Theſ. II.

Of

Of the REGULUS OF ANTIMONY [*], *and its Ore.*

404. I am not certain from any Obſervation, that the pure *Regulus of Antimony* was ever found native; nor do I remember to have read in any Author, of its having been ſetched pure out of the Mine.

405. The Ore of Antimony, is of the Colour of Lead-Ore (§ 373), it has very fine, long, parallel Striæ, in form of Needles, that cut each other acroſs; and more ſeldom ſmall ſhining Scales, with a light reddiſh Colour intermixed; it is heavy, and reſolves partly into a Regulus (§ 16), and common Sulphur, out of either of which, it may likewiſe be eaſily regenerated (§ 333.) by a proper Operation.

Scholion. *The Deſcription of the* Regulus of Antimony (§ 404.) *has indeed a very great Affinity with the Deſcriptions which we have given of ſome Iron-Ores* (§ 351, 352, 353,) *eſpecially* (§ 353); *and there is indeed ſo great a Likeneſs between them, that they are ſometimes confounded with one another. Nevertheleſs, it is eaſy to diſtinguiſh the Ore of Antimony from the reſt, becauſe a ſmall Particle of it applied to the Fire of a Lamp, will melt immediately; which rapacious Iron-Ores can either not be put at all in Fuſion, or at leaſt not without uſing the Blow-Pipe* (§ 258). *Beſides, when a Man has once exactly conſidered the external Habit of all theſe Mines, and filled his own Imagination with the Impreſſion of it, he finds out a certain Difference, which Words cannot eaſily deſcribe, but which is nevertheleſs ſo remarkable, that he is able for the future to diſtinguiſh them from each other, by bare Inſpection.*

Of BISMUTH, *and its Ore.*

406. *Biſmuth* lies ſometimes incloſed ſo very pure in its Ore, that you need not uſe any other Opera-

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[*] The common Antimony to be met with in Shops, hath undergone a Fuſion from its Ore, and therefore our Author calls it *Regulus Antimonii.*

tion to fetch it out, but breaking of it not very fine †.

407. Every Ore of Biſmuth, as is ſhewn by the Chemical Analyſis, is reduced to the State of Ore by Arſenick: For this goes out of it by Sublimation. You find in the ſame Ore that kind of Earth, that gives an azure Colour to Glaſſes, of which we have already ſpoken (§ 325, 326), in the Article of *Cobalt*. Whence it is evident, that the Ore of Biſmuth may without Impropriety be called Cobalt of Biſmuth: The more, becauſe you will find in any Ore of Biſmuth the ſame Principles as in Cobalt, only in a different Proportion.

Scholion. *It will not be improper, here to give an Account of the making of Zafre and Smalt, which* Kunkel *has firſt deſcribed with Clearneſs, in his* Ars Vitriaria. *For Inſtance, Cobalt leaves after the Sublimation, and Biſmuth after the Fuſion, a* Caput Mortuum, *which is in a ſpecial Manner called by the Germans* **Wiſmuth-Graupen**, *when there remains ſomething of the Ore of Biſmuth. It contains an Earth, which being melted together with the Ingredients of Glaſs, gives Glaſs an azure Colour. It is firſt beaten into Powder, then ſifted through a fine Sieve, then mixt, by grinding and ſiercing, with a very fine Powder, made either of Sand or of white Flints, and which is even double in Quantity, with regard to the foregoing. If you ſprinkle with Water this compound Powder, which is called Zafre, the whole will then make a Stone of a middling Conſiſtence: But as this ſprinkling is always done before the Zafre is ſold, ſome have taken it on this Account, for a native Mineral.*

But if you grind and mix this Zafre together with a ſufficient Quantity, for Inſtance, once and a half as much of

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† In the Muſeum of the Royal Society are Pieces of Biſmuth-Ore, ſent from *Cornwall* under various miſtaken Names, but ſo very rich of Biſmuth, that, by only holding a Piece with a Pair of Tongs againſt a clear Fire, the melting Biſmuth will run down in form of melted Tin or Solder, almoſt as ſoon and as eaſy as Cheeſe will drop in toaſting.

Pot-Aſhes, and then melt it in a great Fire; this produces a Glaſs, whoſe Colour is almoſt black; which however, if thrown into Water immediately after it is put in Fuſion, and then ground and ſifted, produces the fineſt blue Powder, which is called Smalt †.

If the ſelf-ſame Zafre, or the Smalt made of it, is mixt with a hundred Times as much or more, of cryſtalline pounded Glaſs, or with any other of the Ingredients out of which white Glaſſes are made; then the Colour which appeared ſo very black in the melted Smalt alone, turns into the moſt beautiful blue ſaphirine Colour: whence ſome pretend, that the Word Zafre *has had its original.*

Of ZINK, *and its Ore.*

408. Zink, is called in German **Contrafait Spiauter**: whether it is or ever was found native, in the ſame Form mentioned (§ 14), is a Secret to me: nor is there any known kind of Ore, out of which this Semi-Metal may be melted in the ſame Manner as the other Metals and Semi-Metals are melted out of theirs.

409. Therefore, all the Zink that is prepared in *Germany*, eſpecially at *Goſlar*, is obtained by Sublimation, not by Eliquation, and not got out of any ſingular Ore, but out of ſuch an intricate and confuſed Mixture of different Ores, that ſeveral other Metals and Semi-Metals may be ſeparated at the ſame Time from it. Iron, Lead, and Copper are alſo contained in it in great Plenty: and are almoſt all involved in Sulphur and Arſenick.

410. There are no peculiar Sublimations made for the extracting of Zink, but, by a Sort of ſecondary Operation; it is collected during the Eliquation of the other Metals, eſpecially of Lead.

411. It is proper here to explain the Manner, in which the Sublimation of Zink (§ 409) is made, becauſe there is hardly any accurate Deſcription of it to

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† See the Note (§ 325.)

be found in Authors. The Ores that yield Zink, are by a long and ſeveral Times repeated Roaſting, freed from Sulphur, and in a Manner from Arſenick by the ſame Operation. When laid into Strata (§ 240.) with Coals, they next are put into priſmatical, quadrangular Furnaces, the Height of which is ſeveral Times greater than their Breadth and Length. Three of the Sides of every ſuch Furnace are ſo many thick Walls; but the fourth, which is in Front, is ſhut up cloſe with Plates, cut out of a kind of Stone eaſy to be cleft, that will bear a ſtrong Fire, and hardly above one Inch and a half thick. There is another Plate made of the ſame Stone, applied within to the inferior Border of the lowermoſt of theſe Plates, and placed in ſuch Manner, that riſing up obliquely and inwardly from the ſaid Border, it makes a Channel declining towards either Side of the Furnace, ending in a Hole left in that Part of the Furnace, and deſigned to carry thence into this Hole, whatever falls into its Cavity. If then the Ores (§ 409.) melt in a great Fire, excited with Bellows, placed below the back-Part of the Furnaces; at the ſame Time the Zink, which is altogether volatile, applies itſelf Drop by Drop to the juſt deſcribed thin, foremoſt, and always leſs hot Wall of the Furnace, and very much likewiſe to the Joints of the ſtony Plates of which it is made; becauſe theſe Joints from Chinks and Furrows that are inequal. In this Caſe, if the ſaid foremoſt Wall of the Furnace is ſtruck lightly many times over, during the Fuſion, the Zink flowing down Drop by Drop, falls into the hollow Channel juſt deſcribed, and is, by its Declivity, determined to run towards the ſmall Hole which is at the End of this Channel, and thence to fall and gather into a ſmall Veſſel put under it. Nevertheleſs, a very great Part of the Zink is burnt and diſſipated during this Operation; which is alſo evidenced *a Priori*, by the eaſy Combuſtibility of Zink in a much milder Fire; and chiefly by the beautiful green Colour of the Flame, that ruſhes out of the Furnaces at that Time, and by the white, thick Smoak that comes out along with it. For you always ſee, and with no ſmall Pleaſure too, a Flame of this Kind, eſpecially towards the End of the Operation. Therefore, out of the vaſt Quantity of Ores, which is at ſeveral Times put into any one of the Furnaces, within the Space of 18 Hours, and which is more than ſixty hundred Weight, not reckoning the additional Ingredients, you will hardly obtain three, four, or at moſt five Pounds of Zink.

Coroll. It is then plain from what was ſaid (§ 408 and 411.) how difficult it is, to paſs any certain Judgment upon the Ore of Zink, as it proceeds from ſo great a Confuſion of Ores and Minerals, and in ſo ſingular a Manner.

412. However, there are beſides the Matrixs of Zink hitherto mentioned, that are found at *Goſlar*, ſome others which may be called *Zink Ores.* To this Claſs belongs eſpecially the *Lapis Calaminaris*, or Calamine, in German **Galmey** and alſo *native Cadmia* to diſtinguiſh it from that which is called (§ 89.) *Furnace-cadmia*. This is of a Figure altogether irregular, ſometimes ſpongy, and now and then ſolid. It is yellow, Gold Colour, red, ſometimes grey, or even of a Colour which is a Mixture of all the foregoing: As for the reſt, it is not very heavy, nor hard: when roughly broken in Pieces, and thrown into a violent Fire, it immediately renders the Flame of the Colour mentioned (§ 14), and exhales a white, thick, copious Smoak, which however has not the Smell of Sulphur or of Arſenick, but a ſweeter Smell peculiar to it, and vaſtly aſtringent, and which condenſates into very light Flowers, which are at firſt bluiſh, and then of a greyiſh White. Only take care not to make this Experiment with ſuch Bits of the *Lapis Calaminaris*, as are accompanied with the yellow ſulphureous Pyrites (§ 316), or with the white Arſenical one (§ 323), or alſo with Lead-Ore (§ 373): for they now and then happen to be aſſociated with this kind of Stone. Beſides, the volatile Part juſt

deſcribed, there is a great Deal of Iron in the Calamine, and moreover no inconſiderable Quantity of unmetallick Earth.

413. You can never, by the only Force of Fire, or by the help of the common reducing Fluxes, produce any Zink out of this Stone (§ 412). However, the Agreeableneſs of the Flowers of the ſaid Stone (§ 412.) with thoſe of Zink; the changing of the red Colour of Copper into the yellow Gold Colour, which Alteration is effected both by the Calamine, and by Zink † (§ 88); and finally, the Production of Zink itſelf out of the *Lapis Calaminaris*, to be obtained by ſeveral manual Operations, require that we ſhould claſs it among Zink Ores: of this more particularly, when we come to the Operations.

414. Some Authors have given us ſeveral Obſervations, concerning the Ores that are proper to Zink, and out of which it may be melted, as other Metals are out of their Ores. But though I would not invalidate their Authority; there are however many Reaſons, why I cannot believe, that the Ores to which they aſcribe the Name of Zink, are ſuch in reality. For, 1. Zink is confounded with Biſmuth by ſeveral Authors: ſo that both theſe Names are looked upon as ſynonymous; while there is nevertheleſs a very great Difference between theſe two Bodies, as it clearly appears from the Characteriſticks of each, exhibited (§ 14, 15), and which are eaſily diſcerned by the Senſes; not to mention greater Differences, between them, which are manifeſted by Chemical Operations. It will be enough, for Inſtance, to mention one ſingle Author, even *G. L. de Lohneyſs*, a Man indeed of no little Rank among Metallurgiſts, and who nevertheleſs, ſpeaking of the Manner in which the Zink of *Goſlar* is got out of its Ore, ſays; *Hoc Zinquum*

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† Out of Zink and Copper may be made as fine a beautiful yellow Metal, reſembling Gold to the Eye, as the famous Bath-metal ſo long in vogue, or a more modern Metal at preſent, in great Uſe for Cane-heads, Buckles, and other Toys.

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ſive Biſmuthum avide ab alchemiſtis deſideratur. See his **Nachricht vom Bergwerck**, p. 83. *b.* 2. Authors have either entirely neglected the Deſcription of the Zink they ſpeak of; or, if they have ſaid a few Words about its Characteriſticks, the very ſame Properties belong likewiſe exactly to Biſmuth. Beſides, Biſmuth-Ores are rather found in many of thoſe Places, which Authors ſay contain Zink in Plenty, than Zink-Ores: for Inſtance, in *England*, the Zink of which Country is very much talked of; though at the ſame Time it ſeems hardly to exiſt at all there: what confirms me more in this Opinion, is a clear Paſſage in *Webſter's Metallographia, p.* 339; wherein this Author owns, that he has to no Purpoſe looked out every where for Zink-Ores, eſpecially in *England*[*].

415. The *Dutch* bring to *Europe* in their *Eaſt India* Ships, a great Quantity of Zink, which is a little more blue than the German Zink, and in every Reſpect more tenacious[†]. But we know nothing certain, either of the Country where the Ore that contains this Zink is digged out, or, and much leſs of the Manner in which Zink is obtained out of it: For they ſay no European is granted the Liberty of entering into thoſe Countries.

Of VITRIOL, *and vitriolick Minerals.*

416. When a Metal or a Semi-Metal is diſſolved by the acid Salt of Sulphur, in ſuch Manner that both may appear under the Form of Salt, when joined together; ſuch a Concrete is ſtrictly called *Vitriol.*

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[*] Theſe are his Words. *I know not, what uſe is made of this Spelter, but only that the Braſiers do mix it with Copper, and thereof make their Cement or Solder; for from them we have it, and that at very dear Rates. The Ore of it I have not ſeen, nor as yet could procure; and I ſhould be very glad to hear that any of it could be obtained, or any of it found in* England.

[†] It is known in *England* by the Name of *Tutinag.*

417. We have hitherto found but two Metals in the mineral Kingdom, that are naturally diſſolved by this Acid of Sulphur, *viz.* Iron and Copper. Therefore, they reckon only two native Vitriols, *viz.* that of Iron, and that of Copper. The former, which is green, ſemi-diaphanous, conſiſting of rhomboidal Cryſtals, and of a ſweet, aſtringent, ſtyptick Taſte, melts firſt in the Fire, and caſts out an aqueous Vapour, and then dries up, and turns into a grey Powder, which, by increaſing the Fire, at laſt becomes of a reddiſh Colour; while at the ſame Time an acid ſuffocating (§ 22.) Vapour is expelled out of it. But the Vitriol of Copper, when artfully ſeparated from the foregoing, and rendered pure, is blue, leſs tranſparent and aqueous, more ponderous, not melting ſo eaſily in the Fire, of a very unpleaſant, cauſtick Taſte; and otherwiſe not very different from the other. Both theſe Vitriols, diſſolved in Water, impart to it their own Colours.

418. Theſe two Vitriols moſt commonly are found joined together; juſt as the two Metals out of which they are extracted, when the ſaid Metals have been diſſolved by the Acid of Sulphur, are hardly ever found ſolitary, but are moſt commonly mixt with each other in many different Proportions. In the mean Time, the Vitriol of Iron is very predominant in theſe concrete Bodies. It is an eaſy Matter to find out, whether there is any Copper in any Vitriol, if you put a well poliſhed Plate of Iron into the Solution of Vitriol: for then there is always ſome Copper driven out, which applies itſelf immediately to the Surface of the Plate, under the Form of a very fine red Powder. But, whether, or in what ſubterraneous Places, the Vitriol of Copper may be found as pure as the blue Vitriol we buy, I indeed know not. That Vitriol ſeems rather to be artificial, which is ſold under the Name of *Roman Vitriol*, *Cyprian Vitriol*, *&c.*

419. Native Vitriol is inherent and diſſolved in many Waters: for Water muſt always concur, to

cauſe the Acid of Sulphur, to aſſume the Form of Vitriol together with the Metal; becauſe no Salt can exert its ſaline Virtue, unleſs it be diſſolved by Fire, or by Water. Beſides, the cryſtalline Form and Tranſparency of Vitriols, can never be procured without the Intervention of Water. But the vitriolick Salts conſtitute many Waters, called on this Account medicinal Waters, as are the *Pyrmont* Waters, and ſeveral others. Wherefore, you may alſo *ex tempore* find out, whether ſuch Waters contain Vitriol, by pouring ſome Water upon a boiled rough Vegetable, for Inſtance upon Tea, Galls, the Herb Tormentil, Snake-weed, *&c.* for this Mixture turns immediately into a black opaque Ink, if there is any Vitriol of Iron mixt with it. But whether the Water contains Vitriol of Copper, will appear, if after having put pieces of Iron into it, they are ſucceſſively conſumed, and the Copper on the contrary precipitated, which is of courſe. Nay, if there is a great Quantity of Vitriol of Copper inherent in the Waters, the Copper, on this Account, being abundantly expelled by the ſaid Pieces of Iron, at laſt grows ſolid, and appears rough and bliſtered on the Outſide, and ſeems to conſiſt within of a great Number of parallel Filaments, and to be more eaſy to break in the Direction of the ſaid Filaments, being otherwiſe of a ductil Nature. In this Caſe, ſuch precipitated Copper is called by the Germans **Coement-Kupfer**; and the Waters which are impregnated with an Abundance of Vitriol of Copper, are called **Coement-Waſſer.** This occaſions the Cuſtom among the Germans, of calling all vitriolick Waters by the Name of **Kupfer-Waſſers**; though they contain a very great Quantity of Iron, and very little Copper.

420. Pure Vitriol is alſo found here and there in the Mines, in a ſolid various Form. It is ſometimes congealed like Water frozen, and is then called *Vitriolum Stalacticum* (§ 357), which is of a green Colour, mixt more or leſs with blue, indicating the Preſence of Copper. It is compact, and is,

neither within nor without, of the Figure it aſſumes when cryſtalized according to Art. They have at *Goſlar* native white Vitriol of this Kind, which being diſſolved in Water, and inſpiſſated again, preſerves its white Colour, and is found no where elſe, as I can remember. It contains Copper and Iron, and ſomething beſides, that is not metallick; the Nature of which is not yet thoroughly known. So that no body, that I know, has been hitherto able to imitate it ſo well, as that the artificial one might not be diſtinguiſhed from the natural. There are beſides ſeveral Germinations, and vitriolick Effloreſcencies within the Mines; and even in the Surface itſelf of the Earth, they are ſometimes of a denſe Nature, ſometimes woolly; they may be found white, green, and bluiſh; an infinite Number of needleſs Names has been given them, which can have no other Derivation, but the infinite Variety both of Figures and Colours, reſulting from a fortuitous Mixture of heterogeneous Matters, and of courſe deſerve to be overlooked.

421. The Ink-Stones, *Lapides atramentarii*, called in German **Atrament-Stein**, are mineral Concretes, in which the Vitriol already perfect (§417.) lies hidden, but confounded ſometimes with many other Earths and Minerals. Whence it again eaſily appears, that the Diverſity of theſe Stones is infinite, with regard to their Weight, Hardneſs, Colour, *&c.* and cannot be determined with Certainty. It likewiſe follows hence, that the various Names, taken from theſe accidental Differences, are altogether uſeleſs, becauſe all the Vitriols extracted out of any one of theſe Bodies, and purified, are entirely the ſame as that already (§417.) mentioned. There are four Species of theſe Stones chiefly reckoned, with regard to the Difference of Colours: *viz.* the black, the grey, the yellow, and the red Ink-Stone. Among theſe, the yellow is very remarkable, by its moſt beautiful but very decaying Colour, by its ſoft Conſiſtence, and by the Quantity of Vitriol it contains. But the others

cannot always be diſtinguiſhed ſo eaſily; nay, they commonly enough reſemble the Ores of other Metals; and indeed ſometimes carry Particles of ſeveral Ores, that have grown together with them. Nevertheleſs, as they contain Vitriol already perfect, the vitriolick Taſte is an infallible Characteriſtick of them all; ſo that they immediately manifeſt themſelves (§ 417.) to the very firſt Taſter that brings them to his Lips.

422. We muſt alſo here ſpeak of the ſulphureous Pyrites of Iron and Copper (§ 316, 347, 369). They certainly have in them all the Principles, that may give Birth to Vitriol (§ 417), *viz.* Copper, Iron, and the Acid of Sulphur. For ſome of the Pyrites of Iron, being expoſed in the Air, ſplit of their own Accord, and turn in part into Vitriol. Of this kind are the pure, merely ſulphureous (§ 316.) Pyrites of Iron: But the Pyrites of Copper, even of arſenical (§ 369, 323.) Copper, do hardly ſo. The others muſt be previouſly roaſted, and expoſed in the Air for ſome Weeks or Months, to produce Vitriol. Of this Kind are the Pyrites of Iron and Copper, and thoſe which have ſomething arſenical in them, together with Sulphur, as is obſerved by the illuſtrious *Henckel.* Nevertheleſs, you muſt make a great many Experiments as to this; for there are ſome Pyrites of Iron, which being expoſed to the Air, will not turn into Vitriol of their own Accord; although they do not contain more Copper or Arſenick, than ſome others, which turn into Vitriol in a few Days.

423. There are alſo many Calamine-Stones (§ 412), which will produce Vitriol, after a previous Roaſting; though they are not of the Pyrites kind, and though you cannot demonſtrate by the Succeſs of any Experiments, that they contain as much Acid, as is neceſſary for the Generation of the Vitriol that is got out of them.

Scholion. *He that is willing to enquire into the meaning of theſe obſcure Words,* Sory, Miſy, Chalcitis, Melenteriæ, &c. *to know the Things they ſignified among* *the Ancients, will perhaps here find the Place to which they belong.*

Of ALLOM, *and the Minerals out of which it is extracted.*

424. Allom (O) is a Salt of a white or a light reddiſh Colour, and of a ſweet ſtyptick Taſte. When diſſolved in Water, and duly inſpiſſated and grown cold, it forms ſemi-tranſparent octoedral Cryſtals, which firſt melt, boil, and foam in the Fire, and emit Phlegm in great Plenty, and then turn into a light, ſpungy, and very white Maſs: But the Fire being increaſed, they at laſt give the ſame acid Spirit as Vitriol (§ 417), or burning Sulphur (§ 312.) do, there remaining a light kind of white Earth, nearly of the Nature of (§ 31, 2.) Marl.

425. Allom (§ 424.) is produced, either out of a black, ſhining, bituminous Mineral, eaſy to be cleft; hence of the Nature of (§ 319.) Sea-Coals, very uniform, but light, ſometimes fibrous, and reſembling Wood; or out of a ſoft bituminous Lump. Theſe Lumps are inflammable, and, when gathered into Heaps, they of themſelves grow hot, and take Fire, ſending forth mean while a fœtid, bituminous, ſtrong Odour, and leaving after they are burnt a kind of ſpongy Earth, that has a little Taſte. But when they do not take Fire, but only grow warm, and cleave; then they become very fruitful of Allom: therefore, you muſt prevent their taking Fire, by pouring a little Water upon them; becauſe their happening to be inflamed renders the Maſſes unfruitful.

426. But the other Minerals out of which Allom is produced, are not bituminous, nor of Courſe inflammable. To this Claſs belong ſome Concretes, reſembling common Clay, that cleave eaſily as likewiſe the Calamine mentioned (§ 412). However the latter, as well as the foregoing (§ 425.) bituminous Species, requires to be gently roaſted previouſly in an open Fire, to produce Allom.

427. It often happens, that, while the Pyrites is preparing for the Generation of Vitriol (§ 422.) a conſiderable Quantity of Allom comes along together with the Vitriol; which may commonly be obſerved in Ink-Stones (§ 421); as theſe often depoſite Vitriol and Allom together, by pouring Water upon them; which however is not common to them all.

428. New, pure, aluminous Minerals, which are not of the Pyrite kind, when chemically examined, yield but very little of the Acid of Allom, or none at all, or at leaſt not a Quantity anſwering to that of the Allom gotten out of them, after they have been a while expoſed to the Air. Nor can one ſee the Earth contained in theſe Minerals, which remains after the burning (§ 424.) of the Allom. The crude Calamine (§ 412, 423.) likewiſe when it is pure, not mixt with any Pyrites, nor accompanied with any ſteel-grained Lead-Ore, appears to contain theſe Principles in a much leſs Quantity. Nor indeed is there any metallick or unmetallick Earth in this Stone, like the *Caput Mortuum* of (§ 424.) Allom. But if we muſt believe that it contains Acid in reality; it is hardly conceivable, how it can lie ſo much concealed therein. Now we leave it to the Judgment and Experience of every body, to determine whether the Acid of Allom, carried by the Air, is thus depoſited in the Matrix of the Allom, according to the Opinion of the illuſtrious *F. Hoffman*[a], or if the new Generation of the two Principles of Allom, that is of the terreſtrial and the ſaline Acids (§ 424.) is made by Means of the Air, or of the Fire, or of both together, as is thought by *Henckel*[b]; but, as it is hardly poſſible to have an accurate Notion of this Matter, before we know the Operations, we ſhall have Occaſion to treat of theſe Things more at large, when we come to our practical Part.

[a] Obſerv. Phyſico-Chemic. L. III. Obſ. 8. pag. 275.
[b] Pyritologia, pag. 756.

Of COMMON SALT, *and the Methods by which it is obtained.*

429. There are in ſeveral Countries Mines eaſily come at, out of which the pureſt, native, common Salt (§ 20.) is gotten in a ſolid Form : it is called *Sal Gem*, or *Rock-Salt*. This Salt is perfectly pure, white, half-tranſparent, and different from the other common Salt, by its large, compact, and apparently homogeneous Cryſtals, which larger Cryſtals produced by Art, are a Collection of many ſmaller Ones: It is much more permanent in the common Air, nor does it contract a Moiſture ſo ſoon as the vulgar Kind of Salt. But theſe ſo very pure Pieces of *Sal Gem* are not found in ſo great Plenty; but, as one may eaſily gueſs, they are now and then infected with other compound Minerals that mix with them. But, when theſe foreign Bodies are mixt with the Salt in large Quantities, it is freed of them, by diſſolving it in Water, letting it ſettle, and then ſtraining it; and finally, by evaporating the Brine (for that is the Name of the Solution of it in Water), the Salt is again reſtored to its ſolid Form. But then it is no longer ſtyled *Sal Gem* *.

430. The whole Ocean, and the ſeveral mediterranean Seas, (or larger Lakes) are full of common Salt: Nevertheleſs, the Waters of them all are not equally ſaturated with it. Some, in one Pound of Water, will have above an Ounce of Salt diſſolved; and ſome others hardly half an Ounce, and even leſs. Above all, the Seas that lie under and about the torrid Zone, are more full of Salt, than the Icy Seas towards the North. The Salt, which is fetched out of them, either by the bare Evaporation in the Sun

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* But Sea-Salt, or the common Salt uſed in domeſtick Affairs.

and the dry Air †, or by being inſpiſſated on a Kitchen Fire, is called *Marine* or *Sea-Salt* ‡.

431. Finally, there are many Springs, the Waters of which are impregnated with common Salt, out of which it is obtained in the manner mentioned (§ 430): They call it *Sal fontium*.

432. Theſe three Species of common Salt (§ 429—431.) do not differ upon any other Account than 1. That of the Place where they are found, and from which they have all their peculiar Names. 2. Of their Purity; for the heterogeneous Bodies mixt with them, ſpoil the Colour and outward Look of the Salt. This is the Reaſon why ſome Brines drop their Salt eaſily, and without any Addition, by bare Evaporation, and ſome others with great Difficulty, or not at all, unleſs you add clarifying Ingredients. Mean while, as ſuch foreign Bodies are not eſſential, but merely accidental to common Salt; they no way conſtitute a real Difference; for any common Salt, provided it be well purified, appears always one and the ſame ‖, after many Examinations. You may read on theſe Subjects *F. Hoffm. Obſ. Phyſ. Chemic.* Lib. II. Obſ. XVI. *G. Agric. de Re Metallica*, Lib. XI. *P. Snellius de Sale communi*, and others.

433. Salt Ammoniac may be referred to this Claſs, as being a ſemi-volatile kind of common Salt. They

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† Is called in Engliſh *Bay-Salt*, the fineſt of which comes from the Rocks on the Coaſts of *Sicily*, and great Plenty of it is prepared in the Salt-Ponds near *la Rochelle* in *France*.

‡ Great Quantities of which is made in *England* by diſſolving Rock Salt in Sea-Water, and evaporating the Water till it bears an Egg, which being ſet to cool, the Salt ſhoots in it in the Form we have it for Uſe; the Cryſtals being firſt dried. The Brine which is poured off, is of a very bitter Taſte, and is therefore called *Bittern*; this again, boiled down, and ſet to cryſtalize, gives a bitter taſted Salt ſo much in uſe of late for Purging, and is commonly ſold under the Name of *Epſom Salt*, from its Reſemblance to the Salt prepared out of thoſe medicinal Waters.

‖ *Bay-Salt* is the moſt impure, having more earthy Particles in it. Concerning the beſt Method of making Salt or Sea-Water freſh and wholeſome to drink, ſee thoſe curious Experiments in a Book entituled *Philoſophical Experiments*, &c. by *Stephen Hales*, D. D. F. R. S. *Lond.* 1739, in 8vo.

ſay, that this foſſil Salt is found native about the Vulcano's, or Mountains that vomit Fire, as alſo in the ſandy, dry, burning Places that are about and under the torrid Zone; and that it is likewiſe evaporated from the Crevices of the Rocks in *Perſia.* But the vulgar Salt Ammoniac which is ſold, is all artificial, and is produced out of the Bodies, which actually, and in reality contain common Salt, or its Acid, and the volatile alkaline Salt. Becauſe theſe are two Principles, of which every Kind of Salt Ammoniac conſiſts, and into which it may be reſolved by Art; therefore the Urine of Animals, eſpecially of thoſe that uſe common Salt; the Soot of many inflammable Bodies, *&c.* yield this Salt. They ſay that the Salt which is brought us from *Egypt*, which is the moſt common, is prepared by Sublimation, either out of the Soot of burnt Dung * of Animals alone, or out of this very Soot mixt again with common Salt, and with the Urine of Animals. See *Acta Pariſina*, and *Boerhaave's Elem. Chem.* T. II. *Proc.* CII. That which is brought from the *Eaſt-Indies*, not in flat convex Loaves, but in conical Ones, like ſugar-Loaves, is rare, and the Manner in which it is made, unknown. It is enough for us to be certain, that every true Salt Ammoniac may be reſolved into the two *Principia* before mentioned, and that likewiſe out of theſe, Salt may be made in every Reſpect perfectly like native or artificial Salt.

Of BORACE, *and its Origine.*

434. We have already (§ 131.) treated of Borace, as of a Menſtruum. It is otherwiſe, though leſs uſually, called *Chryſocolla*, that is, *Gold-Sodder:* tho' at the ſame Time, this Name is much properer to it, than to the green Oker (§ 366.) of Copper; which, though called by the ſame Name, yet is altogether

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* Eſpecially the Dung of Pidgeons, and the Urine of Camels.

different from Borax, and on this Account ought not by any Means to be confounded with it. But the vulgar Borax we buy, which they call (refined) when purified, appears to be in every Reſpect adulterated. That which is crude and called fat Borax, or Tincal, and is brought us from the Eaſt, eſpecially the *Eaſt-Indies*, is certainly very different from that which is called refined Borax. But we know not yet, what additional Ingredients they make Uſe of for the purifying, or rather the adulterating of it: for they look upon it as a Secret. Nor do the Purifyers of Borax willingly admit any Body into their Laboratories, which are chiefly at *Amſterdam* and *Venice*.

435. We obſerve a Figure conſtant enough in crude Borax or Tincal (§ 434): It conſiſts of priſmatical, hexaëdral, nitrous Cryſtals, truncated on every Side, and ſufficiently thick; nevertheleſs, not ſo long or regular, as are the nitrous, nor ſo cloſely joined, as is ſeen in other Salts, but more ſimple and ſolitary, of a bluiſh Colour, pretty hard, ponderous, very difficult to be diſſolved in Water, of a ſweetiſh Taſte at firſt, and then having an alkaline after-Taſte; eaſily melting in the Fire, and not ſo apt to riſe into a Foam, as that called refined Borax.

436. We have not hitherto heard any certain Relation, concerning the Manner in which Borax is primitively obtained; whether it is found native in the Earth, ſuch as it was deſcribed (§ 435); or waſhed out of a certain Matrix, like Nitre, and then by Cryſtalliſation reduced to the already-mentioned Figure: which indeed appears to be more probable than the former.

Of NITRE, *and its Matrix and Generation.*

437. Nitre, or Salt-petre (§ 21), is always ingendered on the Surface of the Earth; it is never gotten out of the Mines; for if you dig into the Earth above one Foot deep, you hardly find any more Ma-

trix impregnated with Nitre: nor is it even found at ſo great a Depth, unleſs it has been by Waters waſhed off from its Matrix, and thus carried lower down together with the ſaid Waters: Which, nevertheleſs, happens in this only Caſe, when the Soil under it is chopped, or of a ſtony, porous Nature; becauſe the Water itſelf can hardly penetrate above two Foot deep into a great many Earths.

438. The chief Matrix of Nitre are calcareous, clayey, loomy Earths, and a kind of moiſt Earth which has all its Origine from vegetable and animal Bodies, deſtroyed by the Viciſſitudes of the Air. If there join to them Aſhes of burnt Vegetables, eſpecially of thoſe out of which a great Deal of fixt alkaline Salt is fetched by Fire; if the ſaid Aſhes are not quite deprived of their Salt by boiling: and if the fat, oily, rottening, or already rotten Parts of the ſaid animal and vegetable Bodies are added; then a perfect Generation of Nitre is performed in the ſaid Matrix: for there is never any Nitre produced in an Earth quite deſtitute of all Phlogiſton: you are only to take care, heedleſly, not to miſtake for Nitre, the calcareous ſtalactical Efflorеſcencies, that are found againſt Bridges and Walls.

439. Nor is it very important, where the already mentioned (§ 438.) Matrix of Nitre be placed: for there never was yet any Place found unfit for the Generation of Nitre, provided the aboveſaid Bodies (§ 438.) do concur to it. However, it is requiſite that the Place be quite in the open Air, and temperate as to Moiſture and Dryneſs: for an exceſſive Humidity waſhes off the Nitre already conceived, and when a diluting Moiſture is altogether deficient, the ſaline Matters hardly act one upon another. In the mean Time, it is certain that Heat and Cold are here neither much uſeful nor noxious, unleſs both be very exceſſive. However, the greateſt Heat of the Sun is to be avoided.

Coroll. It is plain, from what has (§ 437—439.) already been ſaid, that Nitre may be ingendered in all Countries, and that ſome Places are more proper, ſome leſs, for erecting Salt-petre Works. It is likewiſe plain, that moſt probably the Air is either the inſtrumental or the material Cauſe, or perhaps both together, of the Generation of Nitre, or at leaſt carries it in its Boſom. For you infallibly hinder the Generation of Nitre by obſtructing the Paſſage of the Air. The Reaſon is likewiſe plain, why the Eaſt and North-Winds are ſo beneficial to the Places where Nitre grows, in thoſe Regions, and in the Climates between them, eſpecially during the Spring and the Autumn; while, on the contrary, the Weſt and South-Winds are quite unproductive of it. For it has been obſerved, that, in the Spring and Autumn-time, the Eaſt and North-Winds are neither too moiſt nor too dry, eſpecially during the Night; and that, being too drying in Winter and Summer-time, they parch every thing. But the South and Weſterly Winds, being ſtormy, and bringing Rains along with them, are there very hurtful: however, it is well worth our Inquiries, nor have we hitherto found out by Experiments ſufficiently accurate, whether theſe Winds are detrimental to the nitrous Matter, merely by an exceſſive Moiſture, or (ſuppoſing this to be prevented) are hurtful to it upon ſome other Account.

440. Whoever would be pleaſed to make Experiments in theſe Matters, and to do it eaſily, and with little *Apparatus*, might procure himſelf a Nitre-houſe, by expoſing in a proper Place (§ 439.) the Matter in which it is (§ 438.) ingendered. An Example will clear this Point. Chuſe any Place quite open to the Air: However, a Field or a Garden will be beſt. Upon the Area of it, which muſt be eight Foot long, and as much broad and deep, build a ſmall Hut of Mud, having its Top thatched with Straw, and ſloaping, to ſhelter it from the falling Rains: Let the Height of it from the Ground be ſuch, that a Man ſtanding upright may walk under the Roof. Let a Door be made, through which the Artificer may

get into the ſaid Hut, and that may be opened and ſhut. Beſides, leave here and there in the Walls ſmall Windows with ſmall Shutters to them; that you may at Pleaſure admit or keep off the Air from it. Againſt the right, left, and hinder-Walls of this Hut within, contrive ſquare Partitions two Foot long, as much broad, and one Foot deep, divided with wooden-Boards one Inch and a half thick. Fill them with many different Compoſitions of the Things mentioned (§ 438). By this Means, you will be able to make ſeveral Experiments upon this Matter. If you make a Paſte with Mortar *, Aſhes, or moiſt Earth, pouring Urine upon it, and fill one of your Partitions therewith; if beſides, you water it a ſecond Time with Urine, when dry, and beat it well with a Stick, after every ſuch Watering; you will find, in a ſhort Time, that Nitre has ſoon been ingendered in theſe filthy Matters: For, unleſs a very ſevere cold Seaſon happens, a Pound of ſuch a Maſs will, in a Month or two, contain about two Ounces of Nitre. Now the Method of finding out whether there is any Nitre in a Matrix, and what Quantity of it lies hidden therein, ſhall be ſhewn in the ſecond Volume of this Work, when we come to the Operations †.

441. Beſides, the Ores and compound Minerals hitherto (§ 305—440.) deſcribed, there are ſome, whoſe Nature and Principles are not yet ſufficiently known; ſo that they cannot have any certain and determined Claſs aſſigned them. Nevertheleſs, it is beyond all doubt, that they no way belong to the Claſſes of ſuch as yield precious Metals. For Metallurgiſts and Aſſayers, in all the Trials they make about Minerals unknown to them, have almoſt no other View, but that of finding out, whether Gold, Silver, Copper, *&c.* may be extracted out of them

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* Or the Rubbiſh of old Stone-buildings, eſpecially where the Cement hath been Stone-Mortar.

† Salt-petre is brought to us in the greateſt Plenty from the *Eaſt-Indies*, but we are not certain whether it may not be found native in theſe Countries.

with Benefit: and when the Negative is the Caſe, they moſt commonly forbear from any further Inquiry. For this Reaſon, there has been hardly any Mineral hitherto found, that went not through a ſtrict Trial in the ſame View. There are even a great many compound Minerals, among ſuch as have been aſcribed to cerrain Claſſes, which are known only in part, and not at all thoroughly. Of this Kind are, for Inſtance, the Hæmitites or Blood-ſtone (§ 349). The filamentous ſtriated Iron-Ore (§ 353). The ſhining, ſcaly, ſtriated Iron-Ore (§ 352). The native Manganeſe (§ 351) *&c.* the Principles of which are not known, except that Part of them only, that turns into Iron. For this Reaſon, the Iron, which moſt commonly conſtitutes the major Part of the Pyrites, has long been a Secret to the Ancients, who only regarded the Copper envelopped in it: whence, the many Names given to many Pyrites are almoſt all derived from Copper; till at laſt ſome of the Moderns, eſpecially the ingenious Mr. *Henckel*, gave us a compleat Analyſis of them in his Book cited (§ 399) above.

442. Among the Minerals not yet examined (§ 441), that which chiefly deſerves our Conſideration is, the *Molybdæna*, or otherwiſe called *Ceruſſa nigra*, *Plumbum marinum*, in Engliſh *Wad* or *Black-Lead*, in German **Waſſer-Bley**: it muſt not be confounded with the Galæna, or Steel-grained Lead-Ore (§ 373), which, though commonly called by the ſame Name, yet is altogether different from it [*]. The Black-Lead is a Mineral of a Lead Colour, conſiſting of ſmall ſhining Scales, ſoft, ſo as to be eaſily ſcraped with a Knife. It is much heavier than the glimmer-Stones (§ 31. N° 7), of which it has almoſt the whole Texture: it feels much like Soap, and its rubbing

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[*] Formerly, the almoſt only Mine for Black-Lead was in *Barrowdale*, near *Keſwick* in *Cumberland*; but a very large rich Mine of it was ſince found out at *Tantiuſquis* in *New-England* by the famous Governor *Winthrop*, at his firſt ſettling that Country. The aforeſaid Mine is at this Day part of the Eſtate of his Grandſon and Heir *John Winthrop*, Eſq; it is found by the Curious to contain a great Deal of Silver.

againſt ſolid Bodies, renders them ſlippery: whence, Workmen rub their Preſſes, and other Tools, with Black-Lead inſtead of Soap; partly to facilitate Motion, and partly to cover and keep off Ruſt, by ſuch a Lay of a ſhining Black Colour. It is likewiſe commonly uſed for Writing Pencils. It hardly ſuffers any Alteration in the ſtrongeſt open Fire*; except that, being thus divided into very ſmall Particles, it loſes its Colour entirely, and becomes of a Conſiſtence ſomewhat ſofter. We ſhall, when there is Occaſion, in our ſecond Part, at large mention this Mineral, and all the Particulars thereto belonging.

CHAP. VI.

Of docimaſtical Operations.

443. THOSE Actions which change the Objects of the Art, according to the Rules it preſcribes, and by Means of the Inſtruments it employs, are called by Chemiſts *Operations.*

444. All the Changes juſt (§ 443.) mentioned are effected by Solution and Conjunction; ſo that whatever the Chemiſt does may, in general, be eaſily referred to theſe two Claſſes, nor can a third Species of Mutation be imagined, notwithſtanding all ſome can ſay.

445. As the Art of Aſſaying conſiſts in a well-made Separation of Minerals, eſpecially of Metals, and in a Diviſion from each other (§ 1.) of the ſeveral conſtituent Parts of them, that the Quantity and Quality of each in particular may be known; it is plain, that thoſe Operations, which belong to the

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* Black-Lead is of great Uſe for making Crucibles which bear the ſtrongeſt Fire; the Powder of it mixt with Windſor-Loam makes a good Lute for coating Veſſels over with; and it is of great Uſe among the Braſs-Founders, who rub over the Inſides of their Moulds with it.

general Claſs of Solution (§ 444) appertain ſtrictly and primarily to this Place; and that the others, which are performed by the Aſſayer, are only ſecondary or auxiliary Operations.

446. As therefore Conjunctions are to be conſidered (§ 445.) here as only ſecondary; one may eaſily apprehend, that the docimaſtical Operations cannot be divided in general into Solutions and Conjunctions, as chemical Operations are. Nay, any Operation performed by a Chemiſt or an Aſſayer, commonly has the Effect of both the Solution and the Conjunction; ſo that no Solution can ever be performed without a new Conjunction, nor any Conjunction without a Solution. For Inſtance, while heterogeneous Bodies are ſeparated from Gold and Silver by Scorification, do not the Particles of Gold and Silver melt together into a greater Bulk? Likewiſe, do not the Bodies ſeparated, either of their own Accord, or with an Addition of ſome ſcorifying Body, melt together into Glaſs, and thus join again in another Manner? It will then be very wiſely done, always to be attentive to either of theſe Effects in any Operation whatſoever, and to derive the Differences and Denominations of the Operations from the principal of the ſaid Effects, and from the Diverſity of the Apparatus of the Inſtruments (Chap. II. and III.), by which the Changes to be effected are made in the Objects (Chap. I. and IV.) of the Art.

447. But there is hardly any chemical Operation, which is not ſometimes neceſſary to be performed in the Art of Aſſaying. There are many, on the contrary, which are peculiar to Aſſaying alone. Therefore, we ſhall here give a general View of thoſe which belong properly to it, or of thoſe which, tho' taken from Chemiſtry at large, are nevertheleſs very frequently uſed by Aſſayers; and ſhall then add ſhort Deſcriptions of each of them in particular, derived from their primary Differences, their Effects, and the Methods uſed in performing them; that any Novice in this Art may thus be eaſily led to the Practice,

when

when we ſhall attempt to propoſe, in a more exact and clear Manner, ſpecial Obſervations upon every individual Operation.

448. Every primary docimaſtical Operation may, on Account of its Effect, be called Solution (§ 444); ſince, in every Operation, the *Menſtrua*, among which I think the Air and Fire have a right to be claſſed, effect a true Solution, by interpoſing themſelves between the Particles of the Objects to be changed.

Now a docimaſtical Solution *is either*	*Dry*	*Fuſion.* *Vitrification.* *Scorification.* *Coppelling.* *Reduction.* *Amalgamation.* *Sublimation.* *Cementation.*	*Theſe may be called almoſt* Univerſal; *becauſe they diſſolve either the whole Maſs, or at leaſt by much the greater Part of the Subject in Hand.*
		Roaſting. *Calcination.* *Eliquation.* *Precipitation by Fuſion.*	*We may call theſe* Partial, *as they all diſſolve but one Part of the Subject in Hand.*
	or		
	Moiſt	*Elutriation.* *Edulcoration.* *Quartation.* *Moiſt Precipitation.*	*All theſe are* Partial, *and ſeparate ſome Parts from the others.*

449. When the Coheſion of a ſolid Body is ſo diminiſhed by the Strength of the Fire, as that it may become fluid; then it is ſaid to be in *Fuſion*, or *melted*; and the Action itſelf, whereby this Effect is produced, is called *Fuſion* or *Melting*, which is the moſt frequent among the Operations, that are proper to the Art of Aſſaying.

450. All the fixt Bodies hitherto known in the Nature of things may be brought into (§ 449.) Fuſion; with this Difference however, that ſome melt of themſelves in the Fire, and ſome not, unleſs you add to them a diſſolving Body, that is, a Flux (§ 159—166.) There are alſo many among the volatile Bodies, that

may be put in Fuſion; but then they evaporate at the ſame Time.

451. When a Body melted (§ 449.) and grown cold becomes brittle, fixt, not diſſoluble by Water, and melts again when expoſed to the Fire; then it is called *Glaſs*; and the Operation which changes it in this Manner, is called Vitrification.

452. This Vitrification (§ 451.) is made uſe of by Metallurgiſts, to the End, that any Metal impriſoned in a ſolid Body may, on account of its Weight, deſcend and ſeparate itſelf therefrom: and when the Metal itſelf aſſumes the Appearance of Glaſs, this Operation is technically called *Scorification*, in German **Verſchlackung**; and the Glaſs thus produced is called *Scoria*, in German **Schlacke**, in Engliſh *Droſs*.

453. All fixed Bodies experience the ſame (§ 452.) Alteration, not totally excepting even Gold and Silver. There are alſo among the volatile Bodies, ſome that can be fixed, and which aſſume the Form of Glaſs again, by adding fixing Bodies to them.

Scholion. *They alſo call* Scoria *that ſaline Maſs, which is produced by melting Metals and Ores, together with ſaline* (§ 159—166) *and reducing Fluxes: Nor ought, however, the Word* Scoria *to be then underſtood of all this Maſs, but only of the vitrified Particles which adhere between the ſmall Maſſes of the Salts, and which may be ſeparated from them by a Diſſolution in Water, and by Filtration.*

454. It is oftentimes proper, to make the Scorification (§ 352.) in a Veſſel, that may abſorb the Scoria itſelf, and retain the metallick Part. In this Caſe, it is called Coppelling. The Teſts and Aſh-Veſſels mentioned (§ 168, 184, 185,) are deſigned for this Operation.

455. It is then ſelf-evident, that a great Attenuation of the Scoria is requiſite, that it may be able to paſs through the Veſſel. Nor is there any fitter Body for this Purpoſe than Lead, which, by its ſelf undergoing a like Attenuation in the Fire, for this Rea-

ſon diſpoſes to the ſame Attenuation the other Bodies to be reduced into ſo ſubtile a Scoria.

456. There are Earths, which turn into Metal, by being intimately joined with an inflammable Principle: As Metals deſtroyed, and changed into Scoria or Aſhes, are, by their Union with the ſame Matter, again reſtored to their metallick Form. This Operation is called *Reduction.*

457. All Metals and Semi-Metals may be reduced by this Method (§ 456), except Zink; which, being burnt to Aſhes, admits of no Reduction. However, the Mixture of Gold and Silver was never radically diſſolved by any Experiment hitherto known; wherefore, both theſe Metals need not be reduced by the Addition (§ 456.) of Phlogiſton.

Coroll. Therefore, we muſt upon no Account refer to this Claſs, that Reduction by which the foreign Bodies, which do but conceal the metallick Form, are taken away. For Inſtance, Sulphur, Arſenick, Salts, *&c.*

458. The Obſervations to be made concerning Amalgamation, are already clearly hinted (§ 65--68), by what was ſaid, when we treated of Mercury conſidered as a *Menſtruum.*

459. When you are to join to a ſolid fixt Body, by Vapour, another that is volatile, the Vapours muſt be confined, leſt they ſhould be too eaſily diſſipated in the Air; and the Body itſelf, which is to be penetrated, muſt be ſo placed, that the Vapours, very much agitated by the Fire, may as it were continually lick it *. The Manner of producing them has been already (§ 153.) explained, when we ſpoke of the menſtrual Acids, which are to be applied in this Manner to Bodies, eſpecially to Metals. Therefore, as theſe Things are very ſtrictly joined to our Subject, they muſt of Courſe be repeated. But as they moſt commonly, in this Operation, lay firſt one Stratum of the diſſolving Menſtruum, reduced into Pow-

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* Paſs lightly over it.

der, and lightly moiſtened, and then another Stratum of the Body to be diſſolved, upon the foregoing, and then again one Stratum of the Menſtruum, and ſo on; Aſſayers, on this Account, have called this Operation Cementation, from the Analogy it has with the Works of Maſons, when they make Walls.

460. However, there are other volatile Bodies beſides acid Menſtrua (§ 153.) that are joined in the ſame Manner (§ 459.) to fixt Bodies. For Inſtance, if ſuch a Union cannot be made otherwiſe, than by Means of a ſtrong and long-laſting Fire, that may diſſipate the volatile Parts, then, by uſing a Cementation, the volatile Menſtruum, to which you ſometimes add ſome fixing Body, is rendered capable of ſuſtaining a more violent Fire without evaporating, the free Action of the Air being ſtopped; and the Body itſelf, which is thus to be diſſolved, being alſo attenuated, and more opened by the ſame Action of the Fire, is extremely well diſpoſed to receive ſoon the volatile Menſtruum. Thus Arſenick and Sulphur are conveniently united with Iron and Copper, and are eaſily corroded by a ſmall Quantity of Acid, to which they reſiſt more obſtinately at other Times. Pure Iron, impregnated in this Manner with a great Quantity of Phlogiſton, changes into Steel: for, the Action of the Air being ſtopped in this Operation, there are hardly any Bodies totally deprived of their Phlogiſton by the Violence of the Fire. Char-coals are ſo leaſt of any; becauſe, though they were ever ſo minutely pulverized, they ſuſtain for whole Days together the moſt violent Fire, in a Veſſel which is but negligently covered, yet without being quite burnt to Aſhes. But you will in vain expect the Effect deſired, unleſs you uſe an exact Regimen of the Fire in theſe Operations.

461. There are ſome Bodies fixt of themſelves, which may be rendered volatile, by adding volatile Bodies to them; ſo that they are, by different Degrees of Fire, reſolved into dry Vapours. If Vapours thus produced collect together, when you oppoſe to

them the cold Surface of a ſolid Body, that they may apply themſelves to it, they are called Sublimates, and the Operation itſelf Sublimation: but they are chiefly and eſpecially called Sublimates, when they form a ſolid Cruſt; and when they remain only under the Form of a fine Powder, they are called Flowers. The Sublimation is performed either in cloſe Veſſels (which Method is ſufficiently explained in almoſt all the Writings of Chemiſts) or in an open Air, in which Caſe it is particularly called either Geber or Glauber's Sublimation. The latter is not indeed very common, but chiefly known among Metallurgiſts, in moſt of the Operations of which it is always made uſe of, while theſe Vapours apply themſelves to the Walls and Funnels of Furnaces, and form the Scurfs and Flowers of the Furnaces (§ 89).

462. Sublimations are alſo made very well in cloſe Veſſels, by the firſt Method (§ 461); eſpecially if your Glaſs-Veſſels are capable of bearing the Fire: But there are many Foſſils, which, though you uſe the violenteſt Fire, yet prove very refractory in cloſe Veſſels; ſo that you can do but very little, or even nothing at all with them. They, on the contrary, are, by the ſecond Method called Geber's, preſently reſolved into abundant Vapours, in an open Fire, which muſt be blown very gently; as it is eaſy to experience in the Calamine, in the ſeveral Tutties, and the like. But that this Sublimation may be made perfectly, and the Flowers and Sublimates be exactly collected; a particular Apparatus is required, which may be very conveniently made in the following Manner: Inſtead of the Funnel (§ 239. N° 4), put upon the Cover of the melting Furnace a large earthen Pot, not glazed within, of a round Figure, having at Bottom four or five Holes almoſt one Inch in diameter; in ſuch manner, that the wide Orifice of the ſaid Pot, inverted, may be received into the Mouth of the Cover, and the Bottom of it look upwards: then put upon this Pot in an inverted Situa-

tion another of the ſame Kind, ſomewhat ſmaller, bored at Bottom in the ſame Manner as the firſt Pot which was ſet on the Cover: You may, if there is any Neceſſity, put upon this ſecond Pot a third of the ſame Kind, and in the ſame Manner: Secure the Joints of the Cover and Pots on the outſide, with Lute not very tenacious, that the Pots may be eaſily taken away and ſeparated. The Pots, or other Veſſels adapted to this Uſe, are commonly called *Aluduli*, or *Aludels*.

463. *Roaſting*, called in German **Roſten**, is when volatile Bodies are ſeparated from fixt ones by the combined Action of Fire and Air.

Coroll. Therefore this Operation agrees with the Sublimation (§ 461, 462), when a volatile Body, reſolved in Vapours, is collected: becauſe, after this Manner, Sulphur and Arſenick are extracted out of a great many Ores, and are refined.

464. But this Separation (§ 463.) is ſometimes difficult enough; when, for Inſtance, the whole compound Body melts in almoſt the ſame Degree of Fire, that is neceſſary to cauſe a volatile Body to be diſſipated in the Air. Therefore, it is chiefly neceſſary at that Time, 1. Previouſly to pound a little the Body to be roaſted, that its Surface contiguous to the Air may be increaſed: (2.) A gentle Fire is required: (3.) A freer Acceſs of the Air, which is the Vehicle of Vapours. (4.) When the Body roaſting grows into large Clots, the Surface of it muſt be reſtored to its former Extent, by repeating the pounding. (5.) It is neceſſary that the Matter be ſpread wide, and never collected in a Heap. Bodies refractory in the Fire are more eaſily roaſted: for you may conſtantly uſe a great Fire to them, nor need you repeat the Operation ſo often. However, you muſt always take Care, that, while the volatile Bodies are diſſipating, they, at the ſame Time, do not take ſome thing from the fixt ones (§ 461). For this happens in a great many Caſes, when you uſe too impetuous

a Fire in the Beginning: to prevent this, they uſe ſometimes to add ſome fixing Body; of which we ſhall ſpeak in a more ſpecial Manner, in its proper Place.

465. Calcination differs little from roaſting (§ 463, 464), as to the Manner of operating, but only with regard to the Aim of it. For in Calcination (though this be often attended with the Diſſipation of the Volatiles) they only have Regard to the fine Comininuting of the Body. Therefore, by Means of this Operation, the Body falls preſently into Duſt, under the Fire itſelf of the Calcination, or at leaſt ſplits eaſily, when a moiſt Air, or Water, comes afterwards in the Way; which happens in Lime-ſtones: Another Effect of Calcination is, that pliant Bodies aſſume a brittle Texture, as may be obſerved in Metals; and that the hardeſt Bodies may be ſplit, and thus be afterwards more eaſily broken in Pieces: In which Caſe, it is often uſeful all of a ſudden to pour cold Water upon calcined Bodies, even when they are hot to the utmoſt Degree. You have Inſtances of this in Flints, *&c.* Sometimes the Calcination is better performed by adding certain Helps. Thus Tin turns immediately to a Calx or to Aſhes, by adding Lead to it, and by Means of a very ſtrong Fire.

Coroll. Thence it is plain, that you muſt uſe in Calcination the ſame Manner of Operation, as in roaſting (§ 464); becauſe the former is performed by the Separation of the volatile Bodies: Nevertheleſs, it is not ſo in others.

Scholion. *Both theſe Operations* (§ 463, 465.) *are moſt commonly confounded with each other, on account of their great Affinity; ſo that ſometimes Calcination is called Roaſting,* &c vice verſa.

466. When any Part of a compound Body melting in the Fire, is ſeparated from the Reſt, in ſuch Manner, that one Part ſinks to the Bottom, and the other ſwims at Top, this Operation is called Precipitation,

tion by Fuſion, in German Trockene Scheidung *. The inferior, heavier Part is called *Regulus*.

467. This Operation (§ 466.) almoſt always requires the Addition of ſuch Ingredients, as may take away the mutual Connexion between the Parts to be ſeparated; that is, the menſtrual Virtue, by Means of which one keeps the other in a State of Diſſolution. For Inſtance, the reguline Part (§ 16.) of Antimony, and mineral Sulphur (§ 138.) diſſolve each other mutually, and conſtitute crude Antimony (§ 145); nor can they be ſeparated from each other by Fire alone, without deſtroying the Regulus: But if you add Iron, Copper, Silver, &c. which are more thoroughly penetrated by Sulphur (§ 147. *Coroll.* 3), and are thus reduced to the State of Ore (§ 332); then the Regulus of Antimony is freed of the Sulphur; and ſinks to the Bottom, as it is heavier than the additional Bodies then joined to the Sulphur. Such a Precipitation by Fuſion happens in Vitrifications (§ 451), Scorifications (§ 452), and Coppellings (§ 454); while one Part turns into Glaſs or Droſs, the other metallick Part, if there is any, keeping ſtill its metallick Form, is collected at the Bottom of the ſpherical Veſſel. Therefore, Silver and Gold, which are hardly ſubject to a perfect Vitrification, do conſtantly remain, and on this Account, though they were in ever ſo ſmall a Quantity in a Coppelling, they ſhew themſelves very clearly to the Eye, when the Scoria is abſorbed; whereas ſo ſmall a Regulus of theſe Metals would have been as it were buried and hidden under ſo great a Quantity of Scoria. Nor is Precipitation by Fuſion leſs neceſſary, to obtain almoſt all the other Metals, which on this Account are called imperfect; unleſs, perhaps, you except a very ſmall Quantity of native Metal, which, nevertheleſs, can hardly be called truly pure. Beſides, they are all to be had either in

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* That is *dry Parting*, or ſeparating in a dry Manner, without any fluid Menſtruum.

Form of Earth, or in that of a ſolid Ore: in the firſt Caſe, you make Glaſs by a bare Fuſion: in the ſecond, if the Sulphur and Arſenick, which, together with the metallick Part, do conſtitute an Ore, are ſcattered by the Roaſting (§ 463.) the Ore deſtitute of the oily Phlogiſton becomes Glaſs in a pure Fire; which Glaſs may be mixt with unmetallick Stones and Earths: but, by adding Phlogiſton to it, this metallick Glaſs is reduced to its metallick Form, and, ſo long as it keeps under this Form, it cannot be united with the Glaſs of the other Species, but ſinks to the Bottom of it; except only a very ſmall Quantity of it, which is detained by the Clammineſs of the Glaſs. Therefore the precipitating Body here is truly the Phlogiſton. For any Body that takes away the Connexion, by the Removal of which a Precipitation is operated, is called precipitating, in German **Nieder-Schlag**.

468. When ſuch is the Nature of the Ores, or of the metallick Mixtures, that, while one Part of them melts in the Fire, the other more refractory remains ſtill ſolid, then the firſt, melted in a mild Fire, flows out of the Interſtices of the other, and is thus ſeparated. Which kind of Separation is called Eliquation, in German **Saigerung** *.

469. The Perfection of this Operation (§ 468.) requires, 1. the different Fuſibility of the Parts that conſtitute the Maſs. Lead, for Inſtance, melts into one Maſs with Copper in a great Fire; whereas both cannot diſſolve each other in a middling Fire: but if the Maſs, compoſed of both Bodies confounded together, is afterwards expoſed to a mild Fire on an inclined Plane, then the Lead alone melts, and the Copper, become brittle and ſpongy, remains in its ſolid Form. However, this Separation is not ſo perfectly made, but there remains a little Lead in the Copper, and a little Copper is carried away by the Lead: Wherefore, it is requiſite, for this Experiment, that

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* In Engliſh *Smelting*, or running down the Ore.

theſe Metals be not mixed together in too ſmall Proportions: for if one thouſandth Part of Lead was mixt with the Copper, *& vice verſa*; the Eliquation deſired would not ſucceed. 2. It is ſometimes neceſſary to add Ingredients, that may either deſtroy the Force by which the ſeveral Parts cohere together, or even ſometimes procure an eaſier Flux of the Matter: for the Mixtures of the other Metals, cannot without Additions be ſeparated by Eliquation, as Copper and Lead were juſt ſaid to be. For Inſtance, Gold, Silver, and Copper, confounded together, remain in the ſame State in any Degree of Fire. Therefore, to make the Eliquation of the Gold and Silver, out of ſuch a Mixture, you muſt uſe the ſame Additions as in the (§ 467.) Precipitation by Fuſion. Sulphur added in this Caſe, does indeed diſpoſe the Copper to abandon the Gold and Silver: but if theſe two, as it moſt commonly happens, are mixt in a very ſmall Quantity to a very conſiderable one of Copper; then you cannot yet obtain the Separation of them: For beſides, that what we ſaid before (§ 469.) concerning the Eliquation of Copper and Lead, is alſo true here; Sulphur does alſo render Copper fluid, by almoſt the ſame Degree of Fire, by which Gold and Silver are melted. Wherefore, a conſiderable Quantity of Lead muſt be added in this Caſe; that, by Help of it, the Gold and Silver may be diſſolved in a gentle Fire; and thus the Copper be in a Manner waſhed out of them.

470. Both theſe (§ 466, 468.) Operations are of infinite uſe in Metallurgy: for, by Means of them, minute Portions of Gold and Silver, may, without any great Expence be ſeparated from a large Maſs of other Metals: which it has not hitherto been poſſible to effect with Profit, by any other Method. Nevertheleſs, theſe Operations have not been hitherto ſo far cultivated, as that Precipitation by Fuſion, and Eliquation may ſucceed completely in all Mixtures of Metals: for which Reaſon, Metals that are of a

ſmall Price, moſt commonly muſt be deſtroyed, to obtain a Separation.

471. We call Solutions moiſt, when a Body is diſtributed through the very minuteſt Particles of an aqueous, or in great part aqueous Fluid, in ſuch Manner that both may turn into a Fluid to Appearance homogeneous, which goes through all Filters without being detained in them, and the ſmalleſt Part of which contains in it a proportionable Quantity of both the diſſolvent and the diſſolved Body. The Solution of Gold in *Aqua Regis*; that of Silver in *Aqua Fortis*; and that of all Salts in plain Water, are ſo many ſuch moiſt Solutions.

472. That kind of moiſt Solution, by which Silver is ſeparated from Gold by *Aqua Fortis*, is called in Latin *Quartatio* *, and deſerves a particular Conſideration. If, for Inſtance, Silver and Gold are confounded in one Maſs, and the Gold is not leſs than one third Part of the whole Maſs with regard to the Weight; then the beſt *Aqua Fortis* poured upon it is not capable of diſſolving the Silver: but if you add more Silver to this Maſs melting in the Fire; then indeed *Aqua Fortis* poured upon it, when it is grown cold, will corrode the Silver from it: which is alſo the more ſtrongly performed, as the Quantity of the Gold is leſs than one third Part of the whole Maſs. But Experience has taught us, that *Aqua Fortis* diſſolves Silver mixt with Gold quickly enough, when the Gold conſtitutes but one, and the Silver three quarter Parts of the Maſs: Nay, if the Solution is not too impetuouſly performed, the Gold commonly retains in ſuch a Proportion, without any Alteration, the ſame Figure which the whole Maſs had before the Diſſolution; ſo that in this Caſe there is no Reaſon to apprehend, that the Gold torn into minute Particles will be diſſipated in part: which can hardly be prevented, when the Silver exceeds the three quarter Parts of the Maſs with regard to the Gold.

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* In Engliſh *Parting*.

Therefore, Artificers make it their Study, always to obſerve exactly the Proportion juſt mentioned: Whence, the Reaſon and Origine of the Name *Quartatio* †, is ſelf-evident.

Coroll. Now, from what has been ſaid (§ 471.) it is eaſy to conclude, how fallacious the Examination is made with *Aqua Fortis* alone (§ 303.) of the Gold that has been rubbed againſt the Touch-ſtone.

473. Edulcoration * is called a kind of moiſt (§ 471.) Solution, when the ſaline Part adhering to a ſolid Body not diſſoluble in Water, is diſſolved by an aqueous Fluid; and then the Solution is ſeparated from the remaining Solid, either by ſubſiding, or by being paſſed through a Filtre; and this is repeated over and over, till there remains no ſenſible Quantity of the ſaline acrid Body.

474. It is proper in this Operation (§ 473.) to inlarge the Surface of the Body to be edulcorated, by pounding of it; that the Solution may have a ſpeedier Succeſs: for which Purpoſe indeed, they moreover break it in Pieces, or ſtir it with a Stick: That all the Particles of the Body to be edulcorated, which otherwiſe would ſink to the Bottom, may on all Parts be contiguous to the Particles of the waſhing Fluid: by which Artifice all Solutions are facilitated. Likewiſe, boiling Water is ſometimes requiſite: for the Heat, by the inward Motion and Rarefaction it occaſions, promotes in an extraordinary Manner all ſaline Solutions.

475. However, a perfect Ablution of the Salt, is not always obtained by this (§ 474.) Method: for, as every Part of the Menſtruum, contains in it a proportionable Quantity of the Body to be diſſolved (§ 471), and there remains always ſome Part of the Menſtruum in the Body to be edulcorated; it is as evident as Light itſelf, that there remains at the ſame

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† That is, literally tranſlated, *Fourthing*, becauſe the Gold muſt be but one *fourth*, when the Silver is three *fourths*.

* Or waſhing from the Salts.

Time a proportionable Part of the Salt, anſwering to the remaining Quantity of the Menſtruum. Let us take for an Inſtance the ſalt, alkaline, Aſhes of Woods: pour upon them hot Water; make this boil together with them for ſome Time; and then by Decantation or Straining, ſeparate the Lye from the reſt: There will remain at leaſt one quarter Part of the Lye among the Aſhes; and of Courſe alſo a proportionable ſmall Part of the diſſolved Salt itſelf: pour freſh Water a ſecond Time, and decant it: A Quantity of Salt, though much leſs conſiderable, will for the ſame Reaſon again remain; and ſo on for ever. For which Reaſon, this Operation muſt be repeated, at leaſt ſo often as that there remains but a very ſmall and inſenſible Portion of Salt.

Coroll. Hence, the Reaſon is plain, why Calxs of Gold and Silver made with Acids are ſo frequently reduced with great Loſs: for the Acids as yet adhering, being agitated by an impetuous and eſpecially an open Fire, carry a great Quantity of Metal away with them; not even excepting *Aqua Fortis* itſelf; which nevertheleſs, is ſaid to be, and in reality is of a fixing Nature, but that only with certain Limits.

476. Precipitation is called moiſt, in German **Fallung**, when a Body, which has been diſſolved (§ 471.) the moiſt way, is again driven out of the Diſſolvent, ſo as either to ſwim in the Menſtruum, or to ſink to the Bottom of it: which moſt commonly looks like Powder; but the Separation of the Menſtruum from the Body precipitated, is afterwards performed by either decanting, or filtrating.

477. This Operation (§ 476.) is performed, either by extracting, or evaporating in a gentle Fire, the diſſolving Menſtruum out of the fixt diſſolved Body; or by adding ſuch a Body, as is greedily diſſolved by that Menſtruum: as if one Metal diſſolved in an Acid, is precipitated by another Metal, or by alkaline Salt; for Inſtance, Silver diſſolved in *Aqua Fortis*, precipitated by Copper, Copper by Iron, Iron by Zink, and all Metals and Semi-Metals either

partly, or intirely by pot-Aſhes, volatile and urinous Salts. In ſhort, a Precipitation is alſo made by pouring ſuch Things as cannot diſſolve the Body in hand, either alone, or joined to a *Menſtruum* that contains the ſaid Body, or at leaſt diſſolve it in another Manner, or even in a leſſer Quantity, than if the *Menſtruum* had at firſt been uſed pure. In the firſt Caſe, a total Precipitation is performed, as may be ſeen in the Precipitation of Silver out of *Aqua Fortis*, made by Spirit of Salt. In the ſecond Caſe, a great Deturbation and Precipitation is made; but a ſecond Solution ſoon follows: As it happens, when Iron being diſſolved in *Aqua Fortis*, you add to it, in a proper Manner, a Liquor perfectly clear from alkaline fixt Salt: but then there remains moſt commonly a certain Part, which is not perfectly diſſolved a ſecond Time. In the third Caſe, there is but a partial Precipitation made: You will have an Inſtance of this, if Mercury diſſolved in *Aqua Fortis* ſaturated with it, is precipitated by common or ammoniac Salt, or by their acid Spirit. A Precipitation is alſo ſometimes made by adding only a Quantity of Water to dilute: Such is that made with *Regulus Antimonii*, diſſolved in Spirit of marine Salt, or in *Aqua Regis*: For theſe *Menſtrua* do not diſſolve this Semi-Metal, unleſs they are concentrated.

478. All this Precipitation (§ 477.) is helped on by a moderate Heat; by Means of which the precipitating Body enters more eaſily into the *Menſtruum*. Then, you muſt have a conſiderable Quantity of Water to dilute with, except in the firſt Kind of Precipitation: For moſt commonly, the more concentrated Diſſolutions, aſſume the Conſiſtence of a Paſte, ſo ſoon as the precipitating Body is added to them; which hinders this from mixing equally with the Solution.

479. We might annex to moiſt Solutions (§ 471.) the Elutriation *, which is made, when ſolid Bodies

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* Or waſhing with plain Water.

not diſſoluble in Water, are ſeparated from each other by Water very well ſtirred, ſo as that the lighter, together with the more ſubtle Ones, may be forced out of the Water, and the heavier and more ſolid, that is, thoſe which reſiſt more, may remain at the Bottom of the Veſſels. See what was ſaid before (§ 337.) of this Operation.

CHAP. VI.

Of the Effects and Uſe of the Art of ASSAYING.

480. THE chief Effects of the Art of Aſſaying, are to purify Metals, Semi-Metals, and other Foſſils, of all the heterogeneous Bodies they are found mixt with by Nature, and to ſeparate them therefrom: Nor has the Aſſayer any other Aim in all his Undertakings, as will more clearly appear in our practical Part: For which Reaſon we ſhall not at preſent deſcend to Particulars.

481. Nor is it very difficult from thence to conceive, how uſeful and neceſſary is that Art, which at the ſame Time that it conſiſts in the Knowledge and Separation of Minerals, and in the appropriating them to the Uſe of Men, affords beſides an infinite Number of Benefits to Chemiſts, Handicrafts, Phyſicians, Naturaliſts, Metallurgiſts, *&c.* The Art of Aſſaying is nothing but Metallurgy brought into a narrower Compaſs: Therefore, whoever has perceived the Uſefulneſs of the Latter, can never queſtion that of the Former. For if the Properties and Nature of a Mineral found, were not previouſly detected by docimaſtical Operations; who would dare to be at ſo conſiderable Charges, for the making of a greater Apparatus? which muſt be chiefly underſtood of Silver, and of the Gold concealed in it: Becauſe theſe Metals are moſt commonly ſo inti-

mately adherent to other Metals, that they cannot be diſtinguiſhed by the bare Sight.

482. Beſides, Aſſaying is neceſſary to the other Arts, wherein the Knowledge of the Mixture or Pureneſs of Minerals, as well as the Purifying of them, or the ſeveral Compoſitions thereof, are required. For this Reaſon, its Uſefulneſs is very great, chiefly in that Part of Phyſick called the *Materia Medica:* Becauſe there are a great many Minerals made uſe of in Medicines: Therefore, a Phyſician muſt know them, as ſo many Inſtruments of his Art: Unleſs he will run an equal Chance, of either hurting or doing Good, or even of doing nothing at all. This will be eaſily granted by every one that knows, how ſecretly the moſt poiſonous Minerals, ſuch as Arſenick, Copper, Lead, *&c.* lie hidden in all the Species of Minerals: So that all of them, whatever they may be, ought to be previouſly committed to the ſtricteſt docimaſtical Examination, before they are received into the Shops of Apothecaries.

483. But they above all beſtow their Trouble in vain, who being ignorant of the docimaſtical Art, yet attempt to make alchemical Operations, as theſe, among other Particulars, have in view both the Perfection of Metals, and a thorough Knowledge of them. Nor is there any more ridiculous Thought, than to pretend to bring Metals to a greater Degree of Perfection and Pureneſs, and at the ſame Time to be ignorant of the common Knowledge of, and the Manner of ſeparating them, a Title they give to the docimaſtical Art *. Whence it is no wonder, that Quacks and Boaſters very frequently ſpend great Riches about the moſt trifling Operations.

484. The utility of Aſſaying extends alſo to the Art of making Glaſs. When any, for Inſtance, has a Mind to make Glaſſes of the Colour of Jewels †.

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* By way of Contempt.

† Thus are made the *Paſtes* for imitating antique Gems: and on this depends the whole Art of *Enameling*.

For, in order to this, the Calxs of Metals are moſt commonly neceſſary: Becauſe, the Calx of every Metal, even the leaſt Quantity of it, tinges Glaſſes with a ſpecifick Colour. Therefore, that you may with Certainty produce the Colour deſired, it is neceſſary that your Metals be of the utmoſt Pureneſs: Now, this can never be effected without docimaſtical Operations: For, when but one thouſandth Part of Metal mixes to the Tritt of which Glaſs is made, that is to the Mixture of Salts and Flints, to which Litharge or Lead Calx is ſometimes added, your Glaſs is immediately tinged with ſome Colour, whereas it was to have none, but be quite cryſtalline. But if you are willing to give your Glaſs a certain Colour, to be produced by the Addition of one or many Metals, another Metal mixt with it in ever ſo ſmall a Quantity, changes it entirely; hence it is ſo very difficult to give the pureſt Ruby-Colour to Glaſſes.

485. But the Knowledge of the Art of Aſſaying, is likewiſe abſolutely neceſſary, in the making of phyſical Experiments, eſpecially ſuch as have a Relation to the Nature of Fire, and its Effects upon mineral Bodies: That you may know, whether the Body under Trial is pure, or no: Unleſs you have a Mind to indicate an uncertain Cauſe for a certain one, and to ſee always ſome new Event reſulting from the Repetition of the ſame Experiment. I might here alledge many Reaſons, to demonſtrate this Aſſertion: Were I not obliged either to call in Queſtion with great Reaſon, or intirely to annihilate thoſe Experiments, which are ſo much valued by the Multitude, and illuſtrated with Speculations which their Authors are extremely fond of. But *a Word to the Wiſe is enough!*

The End of the Theory of the Art of Aſſaying.

THE ART OF ASSAYING METALS.

PART the SECOND,

Being the PRACTICE of ASSAYING.

Wherein the Manner of performing the docimaſtical Proceſſes is taught.

Preliminary Diſcourſe.

CHemiſts call *Proceſſes* thoſe Apparatus's, by which they perform thoſe Actions, whereby certain determined Changes are produced in the Objects of their Art. Therefore they have been in another Place (Part I. § 443.) called Operations. For as a ſimple Action, when alone, cannot always effect the deſired Change; it is eaſy to conceive, that, not only ſimple Operations, but alſo many of them combined together in a thouſand different Manners, are comprehended in the Proceſſes. Whence it happens, that ſo great, nay, an infinite Number of Proceſſes may be compoſed of the few Operations we have (Part I. Chap. V.) mentioned: For according as theſe are variouſly employed and managed about the ſame Subject, ſo there are many various Proceſſes occaſioned, indeed, and no ſooner, you are capable of determining, whether it has ſucceeded well, or no. Beſides, as Metals, Semi-Metals, and the other Minerals, all of them undergo a Trial, to know whether there is any Silver in them; their Diſpoſition in the Fire and in the ſeveral Menſtrua, appears with the greateſt Evidence in theſe Proceſſes; and by it, the Proceſſes to be made with them afterwards, are indeed very much facilitated. Theſe Proceſſes muſt be followed by thoſe that are made upon Gold: For theſe, in many Reſpects, have a great Affinity with the foregoing; beſides that both a greater Variety of Operations, and now and then difficult manual Works, are met with in theſe. The Reaſon of the Order in which the Proceſſes are to follow each other, with the other Minerals, will appear from the Way itſelf of treating them.

DOCIMASTICAL
OPERATIONS
UPON
SILVER, and its ORES.

PROCESS I.

Precipitation of Silver (Part I. § 452, 467.) *made with Lead; by Scorification, out of its eaſily-fuſible proper* (*ibid.* § 385—388.) *and improper* (*ibid.* § 389—391) *Ore.*

The APPARATUS.

1. POUND the Ore in a very clean Iron-Mortar, into fine Powder. Of this weigh one docimaſtical Centner (*Part.* I. § 275); and eight the like Centners of granulated Lead.

2. Then have at hand the docimaſtical Teſt (*Part* I. *Plat.* I. *Fig.* 7.) which muſt not have as yet ſerved to any Operation: Pour into it about half of the granulated Lead (N°. 1.) and ſpread it with your Finger, through the Cavity of it. Then put upon this Lead the pounded Ore (N° 1), and then cover it quite with the Remainder of your granulated Lead.

3. Put the Teſt thus loaded under the Muffle of the aſſay-Furnace (*Part* I. *Plat.* III. *Fig.* I), and in the hinder-Part of it: Then make your Fire, and increaſe it by the Degrees mentioned (*ibid.* § 235.) If you look through the Hole of either of the Sliders (*ibid. Plat.* III. *Fig*, I. *m. n.*) you will ſoon ſee, that the pounded Ore will be raiſed out of the melted Lead, and ſwim upon it. A little after, it will grow clammy, melt, and be thrown towards the

Border of the Teſt: Then the Surface of the Lead will appear in the Middle of the Teſt, like a bright Diſc, and you will ſee it ſmoak and boil (*Ibid.* § 38). So ſoon as you ſee this, it will be proper to diminiſh the Fire a ſmall Matter, for a Quarter of an Hour; ſo as that the boiling of the Lead may almoſt ceaſe. Then again, increaſe the Fire to ſuch a Degree, that all may turn into a thin Fluid, and the Lead may be ſeen, as before, ſmoaking, and boiling with great Violence: The Surface of it then will diminiſh by Degrees, and be covered over with a Maſs of Scoria's. Finally, have at Hand an Iron-Hook (*Part* I. *Plat.* IV. *Fig.* VI.) ready heated, wherewith the whole Maſs muſt be ſtirred, eſpecially towards the Border; that, in Caſe any ſmall Parcels of the Ore not yet diſſolved ſhould be adherent there, they may be brought down, taking great Care, not to ſtirr any the leaſt Thing out of the Teſt.

4. Now, if what is adherent to the Hook during the ſtirring, when you raiſe it above the Teſt, melts quickly again, and the Extremity of the Hook grown cold is covered with a thin, ſmooth, ſhining Cruſt; it is a Sign that the Scorification is perfect; and it will be the more ſo, as the ſaid Cruſt adherent to the Hook, ſhall be coloured equally on every Side. But in Caſe, while the Scoria's are ſtirred, you perceive any conſiderable Clamminess in them, and when they adhere in good Quantity to the Hook though quite red hot, and are inequally tinged, and ſeem duſty, or rough with Grains interſperſed here and there, it is a Sign that the Ore is not entirely turned to Scoria's. In this Caſe, you muſt with a Hammer ſtrike off what is adherent to the Hook, pulverize it, and, with a Ladle (*ibid. Plat.* IV. *Fig.* XI), put it again into the Teſt, without any Loſs or Mixture of any foreign Body, and continue the Fire in the ſame Degree, till the Scoria has required its Perfection and the above-mentioned Qualities. This once obtained, take the Teſt with a Pair of Tongs (*ibid. Plat.* IV. *Fig.* II.) out of the Fire, and pour Lead

together with the Scoria ſwimming upon it, into a Cone (*ibid.* § 224, 225.) made hot, and rubbed with Tallow. Thus will the firſt Operation of the Proceſs be performed, which does not commonly indeed laſt above three Quarters of an Hour.

5. With a Hammer, ſtrike the Scoria's off from the Regulus grown cold, and again examine whether they have the Characteriſticks (N°. 4.) of a perfect Scorification: If they have, you may thence conclude, that the Silver has been precipitated out of the Ore turned to Scoria's, and received by the Lead.

When the Scorification laſts longer than (N°. 4.) we mentioned, the Lead at laſt turns to Scoria's, or Litharge and the Silver remains collected at the Bottom of the Veſſel: But the Fire muſt be moderately ſupplied, and the Veſſels be extremely good, to produce this Effect; for they ſeldom reſiſt to the Strength of the Scoria's of Lead long enough, ſo as that the whole Scorification of the Lead may be brought to an End: Which has afterwards this Inconveniency, that the Silver is diſſipated by Grains in the ſmall Hollows of the corroded Ore, and can hardly be well collected again, when the Ore has but little Silver in it: Nay, there is ſtill more Time to be conſumed, to obtain the perfect Deſtruction of the Lead, by Means of the combined Actions of the Fire and Air, becauſe the Scoria's ſwimming at the top retard it conſiderably.

The Uſe and Reaſons of the Proceſs.

1. The State of the Silver-Ore depends upon the Preſence of Sulphur and Arſenick: Both theſe, when they are not very ſtrongly inherent to the Silver, and when the Ore is broken ſmall, and extended widely in a ſmall Quantity, are in Part eaſily diſſipated by the Fire, and in Part abſorbed by the Lead (*Part* I. § 76, 174. *Coroll.* 2.) the lighter Part of which ſwimming upon the heavier becomes very clammy by means

by ſmall Holes, lets the Regulus flow out of it. The Veſſels that are moſt ſubject to this Inconvenience, are thoſe in the Materials of which, Lime, Plaſter, and Chalk are mixt: Nay, theſe Bodies, which are of their Nature refractory, being eroded during the Scorification, at the ſame Time communicate a great Clamminеſs to the Scoria; ſo that a great Quantity of the Maſs remains adherent to the Teſt, in the Form of Protuberances, when you pour it out; whereby a great many Grains of the *Regulus* are detained.

6. There are a great many Aſſayers, who take for a Sign of the Compleatneſs of the Scorification, the Quantity of the Scoriæ; that is, when theſe have covered the whole Surface of the Lead. But this is very uncertain: For, if the Teſt is a ſmall Matter narrower, and of Courſe as much deeper, or if you ſcorify Silver-Ores that are leſs rich; then indeed the *Regulus* of the Lead will be covered over with the imperfect Scoria, long before the Scorification is perfect. The Quality of the Scoria is a much ſurer Sign; and this muſt appear quite vitrified, according to the Deſcription of it given (N°. 4. of the Appar.) In the mean Time, the Colour and Brightneſs of it differs according to the Variety of the Ore; however, it is moſt commonly brown, or black, and opaque, which is owing to the Iron and Copper, from which the Ore is ſeldom altogether free; For theſe Metals tinge Glaſſes with very deep Colours. The Colour of the Scoria is ſeldom half tranſparent, reddiſh, or yellow, like Roſin. But when theſe Characteriſticks are wanting, you may be ſure, that all the Silver is not yet precipitated out of the Ore, as it ought to be: Therefore the Fire muſt be increaſed.

PROCESS II.

The Separation of Silver out of the Regulus, Proc. I. *by copelling (*Part I. § 454.*)*

THE Separation of Silver out of Lead, when it has been precipitated, and received by the Lead, may indeed be intirely made by the *Apparatus* of the foregoing Proceſs as well as *(Proc.* I. *Appar.* N°. 5). But this Method is tireſome, on account of the Inconveniencies mentioned in the ſame Place: Therefore, the Thing is better done by coppelling. But for this Reaſon a Scorification muſt precede; that thoſe Bodies, which greatly reſiſt a ſufficient Attenuation to be effected by the Scoria of Lead, may be previouſly ſeparated, and that the Addition of ſo great a Quantity of Lead may not be neceſſary.

APPARATUS.

1. Put into the docimaſtical Furnace under the Muffle, two Coppels of the ſame Bigneſs (*Part* I. *Plat.* I. *Fig.* III.) perfectly dry, and of ſuch Capacity, that they may contain a Regulus, at leaſt one third Part larger than that which is to be put into them: Make a ſtrong Fire, that they may be red hot for a Quarter of an Hour, or more, and the aqueous Vapours vaniſh intirely. Then free your *Regulus* quite from Scoria's, by ſeveral gentle Blows of a Hammer, wrap it up in a clean Paper, and put it into the Fire gently with a Pair of Tongs; taking great Care, that the hollow Surface of the Coppel be not hurt: For which Reaſon, you muſt alſo take Care, that this be not angular or rough. Now, with a Ladle, put into the other Coppel as many Centners of the ſame granulated Lead, which you have uſed (*Proc.* foregoing) for the Scorification of the Ore. All the Phenomena will appear the ſame as we have deſcribed *(Part* I. § 38), and the Scoria's

which are perpetually produced by the Lead, being caſt upon the Border, will be immediately abſorbed by the Coppel, which, on this Account, will be tinged with a yellow, brown, black Colour, in proportion as the Scoria ſhall have penetrated into it.

2. But ſo ſoon as you ſee the *Regulus* boil with Violence and Smoke, diminiſh the Fire a little; that the *Regulus* may for the greateſt Part be conſumed by a middling Heat. You will know that the Degree of the Fire is very great, if the Smoke proceeding from the Lead, is driven up almoſt to the very Cieling of the Muffle, and if the *Regulus* in the Coppel is gibbous at Top: In which, however, the Quantity of the Metal is to be conſidered: For a large Maſs of *Regulus* makes the ſpherical Segment low, and a leſſer one makes it more acute, when the ſame Degree of Fire has been uſed for each of them. Then, if the Coppels are ſo bright with the Fire, as that it be hardly poſſible to diſtinguiſh how far the Scoria has entered, it is a Sign of a ſtill greater Degree of the Fire. But you will know that the Degree of the Fire is middling, if the Surface of the melted Metal is plain, if the Smoke does not riſe very high, and if the Coppel is coloured by the Scoria's, which Signs indicate that the Fire wants a Degree of Force. But if the Smoke wanders to and fro on the Surface of the Metal; if this is almoſt flat, and the Ebullition of the Scoria's, which are like Drops of Fire, is but weak, and their Motion languid, if in ſhort the Coppels appear dark, it is a Sign that the Fire has not its ſufficient Degree of Strength.

3. If you ſee the *Regulus* conſiderably diminiſhed, the Fire muſt ſtill be increaſed: The Lead being thus conſiderably diminiſhed, the bright Sparkles will diſappear, and inſtead of them, you will ſee *Iris's*, as it were, much livelier than in the Beginning and the Middle of the Operation, quickly moving on the Surface of the *Regulus*, and croſſing each other many different Ways. When at laſt all the Lead is conſumed, the tender Skin of the thin Scoria

or Litharge, which being perpetually reproduced by the *Regulus*, had covered the Surface of it, is as it were pulled off. If the Fire at that Time is not ſtrong enough to keep the Silver in a State of Fuſion; the Colour of the *Regulus* of Silver remaining, changes ſuddenly from a faint fire Colour, to a ſhining one: Which Brightneſs is called in German **Blicken.** But if you have uſed in the End ſo great a Fire, as that the pure Silver may be kept in Fuſion, this Alteration of Colour, does not appear, but the granulated Metal continues to ſhine bright. Silver, in the Moment it grows ſolid, commonly emits out of itſelf Ramifications like a Vegetation, and which are ſometimes very delicate and elegant.

4. When the Phenomena above-mentioned (N°. 3) have been ſeen, leave the Coppel ſtill one or two Minutes under the Muffle; then take it out, and with a Pair of Tongs (*Part* I. *Plat.* IV. *Fig.* III.) take away the Metal in Grains: And if any Scoria or any Bit of the Coppel ſhould happen to adhere to it, wrap it up in a Paper, and preſs it between a ſtrong Pair of Tongs or between the Chops of a Vice: That the brittle Droſs may go off without Loſs of the Regulus; which ſhall be very white, and full of ſmall Pits underneath: But if it is tinged with a neat yellow Colour; you may be ſure that it contains a great Deal of Gold.

5. If you want next to determine how much Silver you have fetched out of the Ore, put in one Scale the Silver-Regulus, which has remained of the *Regulus* in the Scorification; and put in the oppoſite Scale, together with the Weights, the *Regulus* which remained in the other Coppel, out of the ſame Quantity of granulated Lead, as you have uſed for the Scorification: For the Lead by which the Scorification has been made contained as much Silver; and this has joined itſelf by the Force of the Operations, to the *Regulus* obtained out of the Ore.

The Uſe and Reaſons of the Proceſs.

1. When you are chuſing a Coppel, you muſt have Regard to the Capacity of it; for Inſtance, whether it anſwers the Quantity of Metal to be put into it, or no. Too large a Size is no way detrimental, but only uſeleſs. Whereas, if it is too ſmall, the Operation does not ſucceed well. For if the Coppel is loaded with too much Lead, the Inſide of it is at laſt corroded and ſplit, by the Litharge into which the Lead is diſſolved, and which finally conſumes every Thing: Nay, if the Aſhes of the Coppel are already ſaturated, a greater Quantity of the Litharge cannot get into it ſo quickly, and that Part of it, which is then abſorbed, runs through upon the Bottom of the Muffle: Which has this Inconvenience, that when the ſaid Bottom being corroded grows inequal, the Veſſels put into it do not afterwards ſtand ſteddy, and are conglutinated to it, if the Heat is conſiderably increaſed.

2. The Coppels, though extreamly old, and to Appearance very dry, like many other Bodies, being nevertheleſs expoſed to a ſtrong Fire, exhale a moiſt Vapour, as we learn from chemical Diſtillations: But above all, the Aſhes of Wood do not eaſily part with the Moiſture they have once contracted, becauſe of the Salt from which they can hardly be intirely freed. Therefore, thoſe Coppels chiefly which are in part compoſed of Wood-aſhes, muſt previouſly be made thoroughly red-hot under the Muffle, without any Lead put into them, that all the Moiſture may be diſſipated This roaſting is called in German **Abathnen.** But if this is not done ſufficiently, the Lead put too ſoon into the Fire, flings to the very Cieling of the Muffle, an innumerable Quantity of ſmall Drops like Sparkles, with a gentle crackling Noiſe. And as this Lead has in it a proportionable Quantity of Silver, it renders the Proceſs uncertain. This emiſſion of Sparkles, when perceived ſoon

enough by the Artificer, may indeed be at any Time prevented, by a large Coal that cloſes the whole Cavity of the Coppel, when put upon it like a Tile: But, as ſome Metal flies off when this Defect is firſt obſerved, and before it can be remedied, on this very Account, an exact Aſſayer can never truſt to ſuch a Proceſs. Beſides, the Operation is alſo retarded by this Remedy: For ſcorified Lead, is often reduced by the Phlogiſton of the Coal; wherefore this muſt be removed ſo ſoon as the Lead begins to reſt. It alſo ſometimes happens, when you neglect to heat the Coppel ſufficiently, that the Lead continually quivers in the Coppel; ſo that it never ſettles; and thus changing its Place, it now and then is in Part thrown out of the Coppel. This Fault may be better prevented, by putting a larger Coal upon the Coppel, than the foregoing: Which proceeds from the Eruption of dry, fat Vapours.

3. Let the Fire be ſomewhat gentler, in the Middle of the Operation of coppelling; leſt ſomething of the Silver ſhould be carried away, by the too attenuated Litharge, and by the Smoke itſelf of the Lead: For in every dry, as well as moiſt and too turbulent Diſſipation of the Volatiles, a Part of a Body howſoever fixt, may at the ſame time be hurried away. That degree of Fire is here ſufficient, by which Lead is changed into Litharge, and attenuated ſo far as to be able to penetrate the Coppel. But when in the End of the Operation, the Lead is almoſt all conſumed, the Fire then muſt be made very ſtrong; leſt ſomething of the Lead ſhould remain with the ſmall Silver-Maſs: Whereby the Weight becomes uncertain, and the Silver is rendered brittle. For Lead is deſtroyed into a ſufficiently attenuated Litharge, by a much leſſer Fire than is neceſſary to melt pure Silver: And Lead acts here as a *Menſtruum*, by which you obtain the melting of Silver in a weaker Fire: For this Reaſon, the more the Lead is conſumed, the ſtronger the Fire muſt be made, than the Quantity of Lead requiſite to retain

the *Regulus* in a State of Fuſion, being once deficient, it may be compenſated by the Violence of the Fire: Which being neglected, the *Regulus* of the remaining Silver hardening too ſoon, a Part of the Lead preſerved from its Deſtruction by the Silver, remains joined to it. Such a reſiduous Part of Lead adhering to the Silver, is called in German Bleyſack.

4. The Operation of coppelling being done, the Grain or Bead of Silver muſt be taken out of the Fire with all Speed; leſt growing cold, it ſhould be conglutinated to the Coppel by the Litharge: For otherwiſe, it can hardly be taken off, without Part of the Coppel adhering to it. The Coppel may alſo be left a while with its Bead under the Muffle, and this is better; that all the Litharge may retire into the Coppel: For then it is very eaſily taken out. As for the reſt, you may ſee *Part* I. § 181. *Coroll.* The Operation of Coppelling being duly perfected, the Bead of Silver will be full of ſmall Cavities underneath.

5. By theſe two Proceſſes (I. and II.) is compleated the docimaſtick Examination of a fuſible Ore, whereby it appears how much Silver may be fetched out of it with Benefit, by a metallurgical Operation: For both being joined, anſwer exactly to the great Operations of Metallurgy. There are ſome of theſe Operations, which thoſe that are well verſed in the Matter, can perform together, at once, and under the ſame Muffle; provided one Veſſel is no Impediment to the other. At leaſt the Coppel may be conveniently heated, at one and the ſame Time, and in the ſame Fire, while the Scorification is performed in the Teſt.

6. There is no Lead ſold, but contains ſome Silver: For it is not always worth the Charges of ſeparating it. Such a little Maſs of Silver moſt commonly is one or two Drachms in every Centner of Lead. Therefore, it occaſions a very great Error, when it is left in the Coppel, and joins to the *Regu-*

lus ſeparated from the Ore after the Lead is conſumed: For which Reaſon, this increaſing of Silver is always ſubſtracted by all accurate Aſſayers. Therefore, a conſiderable Quantity of Lead is granulated at once for this Purpoſe, and well mixt by ſifting: Then this granulated Metal alone, muſt be tried in a Coppel, in the ſame Quantity uſed to make the Trial of Ores; that you may have ſeparately the Bead of Silver it contains. For this, while the *Regulus* of Silver, ſeparated from the Ore by the ſame Kind of Lead, is weighing, is put into the other Scale which contains the Weight; to take away the Overplus of Weight, that was added to this *Regulus*, by the ſame Quantity of the Lead imployed for the Scorification and Coppelling. But whenever a Granulation of new Lead is made, the determined Quantities of it commonly imployed for the trying of Ores, muſt be as many Times tried in the Coppel; even though you knew, that the Lead had alſo been digged out of the ſame Mine as the firſt, and melted out of its Ore in the ſame Manner. For while Lead is ſmelted, Silver is not very equally diſtributed through it: Which proceeds from many Cauſes, of which hereafter.

7. However, we muſt alſo obſerve in general, that all the additional Ingredients, which we uſe in ſuch Operations, muſt be tried, to know whether they let any Silver fall into the Regulus of Lead, and how much. For the Litharge itſelf is ſometimes loaded with Silver. Therefore, it is proper to try it itſelf in the Coppel, or the Glaſs of Lead made out of it, before they are imployed. Copper, Iron, and other Metals, are ſeldom altogether deſtitute of Silver: And though they contain ſo little of it, that the Error proceeding therefrom is hardly ſenſible; nevertheleſs, you muſt beware of the minuteſt Miſtakes: For a great Number of them, though ever ſo inſignificant, conſtitute, when collected together, an Error, which is not inconſiderable.

PROCESS III.

To precipitate with Lead by Scorification, Silver *out of an Ore that cannot be waſhed clean, and which is rendered refractory, by a Mixture of unmetallick Earths* (Part I. § 334, 336, 338.)

THE Variety of thoſe Things which render Ores refractory require a different Manner of treating them. But there are ſome Ores rendered refractory, by a Mixture of an unmetallick Earth, ſome of which are, and ſome are not ſeparable by waſhing. If they are not ſeparable, you muſt proceed in the following Manner.

APPARATUS.

1. Bruiſe the Ore into an impalpable Powder by grinding in a Mortar; to a docimaſtical Centner of it, add a like Quantity of Glaſs of Lead (*Part* I. § 54.) finely pulverized: For the more exactly both theſe are mixt together, the more eaſily the Scorification afterwards ſucceeds. Put this Mixture, together with twelve Centners of Lead, into the Teſt, according to the firſt Proceſs (N°. 2.) then put the Teſt under the Muffle.

2. Make firſt under it a ſtrong Fire, till the Lead boils very well: When you ſee it ſo, diminiſh the Violence of the Heat, according to the firſt Proceſs (N°. 3.) but keep it thus diminiſhed a little longer. Then, finally, increaſe the Fire again to ſuch Degree, till you perceive the Signs of a Scorification and perfect Fuſion. See the whole Proceſs I. Now, this Proceſs laſts a little longer than the foregoing, and requires a greater Fire towards the End.

3. It ſometimes happens, that a very refractory Ore cannot be ſufficiently diſſolved by Litharge; and that a Maſs which has the Clamminеſs of Pitch, ſwims upon the Regulus, and upon the Scoria's

themſelves which are already ſubdued in part: When you ſee this, ſhut the Vents of the Furnace, to diminiſh the Fire: Then gently touch this refractory Body, with a ſmall Iron cold Hook, to which it will immediately ſtick; take it off ſoftly, not to loſe any Thing; pound it into a fine Powder, adding a little of Glaſs of Lead; and put it again into the Teſt, then continue the Scorification, till it is brought to its Perfection. But you muſt always examine the Scoria of your refractory Ore; to ſee whether there may not be ſome Grains of the *Regulus* diſperſed in it: For ſometimes the Scoria's that grow clammy, retain ſomething of the Metal: Which if you ſuſpect, pound the Scoria into a fine Duſt, and thus the Grains of Metal will appear, if there are any left; becauſe they can never be pounded fine.

4. Silver is ſeparated out of the *Regulus* by copelling (N°. 3), according to Proceſs II. But while you are weighing the *Regulus* of Silver obtained, you muſt put into the oppoſite Scale, the ſmall Maſs of Silver, which has remained in the Coppel, out of the twelve Centners of the Lead employed. (See Proceſs II.)

The Uſe and Reaſons of the Proceſs.

1. All Earths and Stones are refractory in the Fire: For though ſome of them melt naturally in the Fire, as thoſe that are vitrificable do; nevertheleſs, all the others, a very few excepted, melt much more difficultly than Metals, and never become ſo thin in the Fuſion, as is required for the ſufficient Precipitation of a precious Metal. But Litharge itſelf does not conveniently diſſolve theſe refractory Matters by the Help of Fire alone, unleſs you add ſome mechanical Mixture to them: For the very Moment the ſaid Litharge penetrates through the Interſtices of the refractory Ore, and begins to diſſolve it, a tenacious Maſs is produced, which hardly admits any further Dilution by the Litharge. You may ſee it plain, if you make Coloured Glaſſes with metallick Calxs: If you

ſaturate the Metal that lies hidden in them. For which Reaſon, this ſuperfluous Sulphur diſſipates in a middling Fire: But if it had been mixt with Lead, it would have rendered it refractory; nor could it afterwards be diſſipated from it (*Part* I. § 142.) without a conſiderable Deſtruction of the Lead. The white arſenical Pyrites, turn alſo a great Quantity of Lead into Glaſs, on account of the Abundance of the Arſenick they contain. For which Reaſon, theſe Ores muſt be previouſly roaſted, that the Sulphur and Arſenick may be diſſipated: Nor need you fear, leſt any Part of the Silver be carried away by the Arſenick: For when Arſenick is ſeparated from any fixt Body, by a certain Degree of Fire; it carries nothing of that Body away with it (*Part* I. § 74, 329.)

2. Every Pyrites has Iron for its Baſis: But this is not only refractory of its own Nature, but has much ado to melt into a thin Scoria even with the Glaſs of Lead.

3. Near a-Kind to theſe is an unmetallick Earth, annexed in great Plenty (*Part* I. § 316, 323.) to every Pyrites. Therefore, after the Sulphur and Arſenick are diſſipated, the only Thing remaining to be done, is, to uſe the Methods we have deſcribed in the third Proceſs.

PROCESS V.

Precipitation of Silver out of Iron, by Scorification.

APPARATUS.

1. PUT one Centner of Iron reduced to Filings, or to thin Lamina's, into a glaſs Cucurbite cut off in the Middle, the Belly of which muſt be luted over; then pour upon it as much Oil of Vitriol, diluted in about eight Times the ſame Quantity of Water, as is required for the Diſſolution of Iron: Put the Cucurbite again upon the Aſhes or a warm

Bed of Sand; that the Diſſolution may be made by a gentle Heat: This being perfect, put burning Coals under it, that the boiling Diſſolution may thicken by Degrees; till the remaining Maſs be intirely dry, of an aſh-Colour, and hard: When you ſee it ſo, then urge the Fire, till the Veſſel grows red-hot: Thus will the Oil of Vitriol be for the greateſt Part diſſipated: But there will remain at the Bottom a pulverulent, dark red *Caput Mortuum*, which muſt be taken out of the Veſſel, without loſing any Thing of it.

2. Divide this into two equal Parts, and grind each of them ſeverally with a Centner of Glaſs of Lead: Put any one of theſe Mixtures, together with eight Centners of granulated Lead, into a Teſt, and compleat the Scorification, in the Manner deſcribed in the third Proceſs.

3. Burn off the remaining *Regulus's* ſeparately in two Coppels, according to the ſecond Proceſs, and weigh the remaining Beads of Silver: They will be both of equal Weight. Then ſubſtract the Silver proceeding from the Lead added: And thus you will know, how much Silver may be fetched out of a Centner of Iron.

Another Method.

1. Put one Centner of comminuted Iron, and two Centners of crude Antimony, into a ſmall Crucible, and cloſe it with a Tile, and then put it into a ſtrong Fire, that it may melt: When it has been in a perfect State of Fuſion for five or eight Minutes, take it out, that it may cool.

2. Break the Crucible when grown cold: You will find Scoria's at Top, and a *Regulus* underneath: Throw the firſt away, and pound the *Regulus* to a fine Powder, and ſcorify it with twelve Centners of Lead, upon a continual, though not over-ſtrong Fire; till you ſee the Lead quite covered with Scoria's: Then pour it out into a Funnel; nor are you

to take ſo much Notice of the Scoria's, as of the *Regulus*; which muſt be tough, and of a light Lead-Colour within and without. If it proves blackiſh and brittle, it then is not fixt yet to be put into the Coppel, but it muſt be put into the Teſt a ſecond Time, and the Scorification be repeated: Thus will all the Antimony be at laſt conſumed.

3. Let the Coppelling be performed, as in the ſecond Proceſs.

The Uſe and Reaſons of the Proceſs.

1. Iron, in its metallick State, yields neither to Lead nor to Glaſs of Lead. But when it is deſtroyed by the Privation of its Phlogiſton, and diſpoſed for a Vitrification, it is eaſily diſſolved by the Scoria or the Glaſs of Lead; and melts together with it into a thinly fluid black Glaſs. He therefore that attempts a Scorification, muſt previouſly pound this Glaſs very fine, becauſe this promotes very much the Diſſipation of the Phlogiſton; which is eaſily obtained by acid Spirits diſſolving Iron; but moſt perfectly by Oil of Vitriol: For this deprives Iron of Part of its Phlogiſton, during the Solution itſelf: As we may ſee from the inflammable Spirit that ruſhes out, and is produced in the actual Solution not only of Iron, but alſo of Copper and Zink. The ſame Comminution and Deſtruction of Iron, is alſo performed with Sulphur, if this is mixt with Filings of Iron, and melted firſt in a cloſe Teſt by a gentle Heat, and finally burnt intirely in a ſtronger Fire: But the Diſſolution is never made ſo perfect thus, as by the firſt Methods: For the Sulphur is much ſooner burnt, before it can ſufficiently penetrate the Iron. Sulphur poured upon red-hot Filings, diſſolves them indeed; but then it can hardly be taken out of the Veſſels; on which Account it is not rendered ſo proper for a Scorification, as by the firſt Method, unleſs it be beaten ſmall and roaſted a ſecond Time: The very ſame Operation is much better performed with a yellow,

low, ſulphureous Pyrites, which hath been thoroughly proved to be deſtitute of Silver; if it is ground together with an equal Weight of Filings of Iron; and expoſed to the Fire, in the ſame Manner as was ſaid about Sulphur. The Sulphur, however fixt in the Pyrites, requires a great Fire to be expelled; and by Means of that Heat penetrates and diſſolves the Body of the Iron at the ſame Time, till at laſt, the Fire being made ſtill greater, it is intirely diſſipated. But this Method has the Inconveniency, that the Maſs of the deſtroyed Iron is greatly increaſed, and rendered more refractory by the unmetallick Earth of the Pyrites: Wherefore the preſcribed Quantity of Lead, is not ſufficient in this Caſe; and twelve Centners muſt be added to each Part.

2. Crude Antimony is the moſt potent *Menſtruum* of Iron, partly on Account of its reguline Subſtance, and partly becauſe of the mineral Sulphur that conſtitutes about one quarter Part of it. Therefore, a double Quantity of it, mixt with Filings of Iron, diſſolves them ſoon, in a middling melting Fire; but then at the ſame Time the Iron abſorbs the Sulphur of the Antimony (*Part* I. § 147. *Coroll.* 3), and together hinders the Sulphur from getting into the Silver; becauſe Iron is a greater Friend to Sulphur (*Ibid. Coroll* 1): Therefore, Silver with one Part of *Regulus* of Antimony (which both diſſolve each other alike) ſinks to the Bottom; and it is, as it were, waſhed clean of the Iron (*Part* I. § 467.) by the ſaid reguline Part. But, that this Precipitation may ſucceed perfectly, a pretty ſtrong Fire is required, and muſt be continued for ſome Time; and it would not be amiſs, if a little of the Iron ſhould ſeparate and turn into a *Regulus*. Nor muſt the *Regulus* be poured out into an Iron-Cone, but muſt be left in the Crucible, and be taken out of it, by breaking it when grown cold: For ſo ſmall a Quantity of Scoria, being too ſoon cooled, would eaſily retain ſomething of the reguline Part together with the Silver. Therefore, this *Regulus* muſt be previouſly

ſcorified

ſcorified with Lead: Becauſe the Coppel cannot bear any *Regulus* of Antimony: For when this is joined with Lead, it ſplits the Coppels, and often corrodes them to ſuch a Degree, that the whole Inſide of them ſwells like a Spunge. Therefore, after the Scorification, you muſt have Regard to the *Regulus* alone, to know whether its Brittleneſs and black Colour, communicated to it by the *Regulus* of Antimony, will require the Repetition of the Operation. But, you are previouſly to examine, whether the Antimony contains Silver in it: Which may be done intirely by the ſame Method already deſcribed relating to Silver. For the *Regulus* and Silver is precipitated out of crude Antimony by Iron, Copper, Lead, and Tin. But, before this Examination is made, all theſe Metals muſt be tried likewiſe, to know whether any Silver remains of them after the Scorification and the Coppelling, and what Quantity.

3. As Iron is of ſuch Diſpoſition in its Ore, that it turns into Glaſs, by means of Fire alone, on account of its Want of a pure Phlogiſton; it is plain enough, why Iron-Ore is fit to be ſcorified with Lead, without any previous Diſſipation of its Phlogiſton: Although it be the only Ore refractory to ſuch a Degree, as not to be brought without great Difficulty to a ſufficient Degree of Fuſion, unleſs it be joined to a great Quantity of mineral Sulphur, or Arſenick.

PROCESS VI.

Separation of Silver from Copper, by coppelling.

1. REduce the Copper into Filings, or thin Plates, which you muſt cut into ſmall Bits with a Pair of Sheers: Weigh one Centner, or one Mark, of either; and ſixteen times the Weight, with Regard to the Copper, of granulated Lead: Put the latter with a Ladle into a large well-baked Coppel; make a great Fire, and continue it ſo, till the Lead begins to ſmoak well and boil: Then add the Cop-

per wrapt up in a ſmall Paper, ſo that it may be immerſed into the Middle of the boiling Lead: This preſerves the Copper, which adheres to the Border, from being difficultly, or even not diſſolved at all.

2. When all the Copper is diſſolved, ſuppreſs the Fire, till you ſee on the Surface of the juſt-melted Lead a Smoak wandering here and there, and the metallick Maſs not very high nor bright, but low, moderately white, and the Coppel brown, as far as it has been penetrated by the Litharge. However, take Care that the Ebullition of the Lead does not ceaſe intirely: For it is a very good Indication of the Degree of the Fire. If you employ too great a Fire, you will certainly loſe ſome of your Silver; eſpecially, if you are not provided with the beſt Coppels.

3. When you ſee the greateſt Part of the Metal already conſumed, increaſe the Fire gradually, and make it pretty ſtrong towards the End, that it may burn quite bright and clear. Then take out the Coppel; and if the Operation has been rightly made, you will find the Bead of Silver, if there was any in the Copper, quite bright, and ſurrounded with bright Scoria's of a yellow Colour, in Form of Cryſtals. The Coppel is always tinged with a dark Colour. But if you perceive the Grains of Silver, either quite dark, or only the Surface of it tarniſhed with dark-coloured Scales; it is a Sign, that there is ſtill a great Deal of Copper mixt with it: Which muſt be attributed to the Defect of the Fire or of the Lead, or to the too late Immerſion of the Copper into the boiling Lead: For then, a conſiderable Part of the Lead being conſumed, the remaining Part has not the Power of conſuming the Copper ſufficiently. But if all the Scoria is intirely vaniſhed, you have uſed too great a Fire in the Middle and towards the End of the Coppelling: In which Caſe, you muſt, for the greater Security, repeat the Proceſs.

The Uſe and Reaſons of the Proceſs.

1. Among all Metals, and all the Minerals which are ſeparated from Gold and Silver by Lead, Copper is the only one that remains joined to the reſiduous *Regulus* of Lead after the Scorification, and is fit to undergo the Coppelling: For the others either are not at all received by Lead; or, if they are, it rejects and deſtroys them before the Scorification; or, if they remain united with the Lead, they ſplit and corrode the Coppels. The Coppels are alſo eaſily ſplit, eſpecially the larger Ones, when you put Lead into them before they are quite red-hot.

2. The Scoria which is produced during this Proceſs is indeed that common Litharge, which is ſold: It is a Texture of ſmall ſcaly Lamina's looking like Glimmer, and if you break it, it reſiſts like other Litharge, by a certain Toughneſs.

3. There is no Metal but Copper alone, that melts together with Lead into one Maſs, and dies the Coppels with a blackiſh Colour. Therefore, when you ſee this, you may ſafely conclude, that there is Copper in the Lead.

PROCESS VII.

Precipitation of Silver out of Tin, by Scorification.

APPARATUS.

1. Divide one ſingle Centner of Tin into two equal Parts: Put each of them into a ſeparate Teſt, and add to each ſixteen Centners of granulated Lead, and one of Copper: Put the whole under the Muffle, and make a very ſtrong Fire: The Tin will be calcined immediately, and ſwim upon the Lead (*Part* I. § 41.)

2. Then diminiſh the Fire a little; till the Aſhes of the Tin that ſwim at Top, do no longer ſparkle:

When you ſee this, add with a Ladle two Centners of Glaſs of Lead into each Teſt; in ſuch Manner, that it may be ſpread wide, through the whole Surface of the rejected Calx. Thus the Calx of the Tin is ſo much involved and penetrated by the Glaſs of Lead, that at laſt it changes its Form of a Powder, into the tenacious Form of Glaſs. If you perceive this, increaſe the Fire to its higheſt Degree; ſtir up the Scoria's with a warm Poker, and when you have ſeen the Signs of a compleated Scorification, pour out the Maſs; and for the reſt, obſerve here the ſame Things, which we preſcribed in the third Proceſs.

3. The Scoria's being ſeparated, put both *Regulus's* into two Coppels well heated; and put into a third Coppel ſixteen Centners of Lead, and one Centner of the ſame Copper which you have uſed for the Scorification (N° 1.) of Tin; that you may be able to determine, how much Silver, Copper, and Lead, theſe Quantities contain, which muſt be afterwards ſubſtracted (*Proc.* II. N° 5). For if you neglect to do this, you cannot be ſure of having ſeparated the Silver from the Tin. Let the Regimen of the Fire be the ſame during the Coppelling, as in the ſixth Proceſs. But the other two firſt *Regulus's*, muſt weigh the ſame in the Balance: If not, the Proceſs muſt be repeated.

Another Method.

1. Reduce your Tin into thin Lamina's or into Filings; or, if it is brittle, pound it to a fine Powder: Then put two half Centners of it into two ſeparate Teſts; put them under the Muffle, and make a middling Fire, that they may turn to Aſhes: Then take out the Teſts: Mix with each Part of the Aſhes two Centners of Glaſs of Lead, and then put each ſeparate Mixture with twelve Centners of Lead into the ſame Teſts, and perform the Scorification in the ſame Manner as in the third Proceſs. But make the

pelling according to the ſecond Proceſs. And thus will the Operation proceed without Copper.

2. The Calcination of Tin is more ſpeedily performed, if you put into the Teſt half a Centner of Tin upon twelve Centners of Lead, and lay it on the fore-Part of the Muffle that is leſs hot: For then the Tin will be perfectly calcined in a few Minutes. Then take out the Veſſels; let them grow cold, that the Aſhes may be collected; mix them with Glaſs of Lead, and, finally, ſcorify them upon the ſame Lead and in the ſame Teſt, as before (N° 1.)

The Uſe and Reaſons of the Proceſs.

1. The firſt Method by which the Scorification is performed with Copper, is more ſpeedy than the foregoing: But, on account of the Copper added, you muſt not only add an enormous Quantity of Lead, becauſe Copper requires ſixteen Times the Quantity of Lead to be deſtroyed (ſee the ſixth Proceſs), but you muſt beſides examine alſo ſeparately in a Coppel, whether the Copper contains any Silver. The two laſt Methods are cleverer; but they can hardly be perfectly executed in two Hours: Becauſe the Scoria of Tin, without adding Copper to it, is with great Difficulty brought to the ſame Degree of Perfection, as when Copper is added.

PROCESS VIII.

To examine the Allay of Silver with Copper, by Coppelling.

APPARATUS.

1. RUB the Metal upon the Touch-ſtone well wiped, and compare the Proof-Needles; to know nearly what the Proportion of the Mixture is, and of Courſe how much Lead muſt be added, to conſume all the Copper: But as the Lead neceſſary for

or the conſuming of the Copper, is not in a Quantity proportionable to that of the Copper, when his is mixt with Silver; we ſhall here indicate the Quantity to be added in every Caſe which was preſcribed by *Erker*; though ſome others differ very much from him. But we ſhall take for our Example a Series of Needles, made according to the Mark divided into half-Ounces and Grains (*Part* I. § 290).

½ *Ounce. Sil.*	½ *Ounce. Copp.*	*Marks of Lead to be added.*
15 ½	½	4
15	1	6
14	2	8
12 & 13	4 & 5	10
9 — 12	7 — 4	14
4 — 8	12 — 8	15
1 — 4	15 — 12	16

Every Body may eaſily reduce this Table to the Needles made according to the Mark of the Avoirdupoids, or that of Karats: Nor is it neceſſary to proportion the Quantities of Lead to be added, ſo far as one half-Centner.

2. In the mean Time, let the Metal to be tried with the Needles, undergo the Operation of Coppelling, together with the Quantity of Lead indicated (N° 1), as in the ſixth Proceſs. Only you are to obſerve concerning the Regimen of the Fire, that you muſt make it the gentler, as the Silver is allayed with a greater Quantity of Copper; and on the contrary, the ſmaller the Quantity of the Allay of Copper is, the ſtronger muſt be the Fire to be uſed in the Operation. As for the reſt, all we have ſaid in the ſixth Proceſs doth likewiſe belong to this.

The Uſe and Reaſons of the Proceſs.

1. Pure Copper, in whatſoever Quantity, is intirely conſumed by ſixteen Times as much Lead: But it is quite otherwiſe, when it is mixt with Silver: For Copper is the more defended by the Silver, in Proportion as it is in leſſer Quantity mixt with Silver, and *vice verſa*. For Inſtance, half an Ounce of Copper is conſumed in the Coppel by ſixteen half-Ounces of Lead: But if one half-Ounce of Copper is confounded in the Fire, with eight half-Ounces of Silver, ſixteen half-Ounces of Lead will never ſuffice, to deſtroy the whole half-Ounce of Copper. Now, if you have found out by Experiment, the leaſt Quantity of Lead that is ſufficient, and repeat the Experiment anew, with half an Ounce of Copper mixt with ſixteen half-Ounces of Silver; you will ſee, that the ſame Quantity of Lead, which in the firſt Caſe had the Power of compleating the Purification of the Silver, is by no means ſufficient, to convert the whole Copper into Scoria; and that ſome more Lead muſt be added: and ſo on.

2. Thence you may derive the Reaſon why Silver cannot be intirely freed from all Copper by copelling? Beſides, you will never buy any Lead, that is altogether void of Copper: For you will find in no Place any Heap of the pureſt Lead-Ores, that are not ſlightly mixt with Copper-Ore, or Pyrites. Now, the perfect Separation of ſuch a ſmall Quantity of Copper, which is indeed very difficult, would never repay the Charges of it; wherefore, it remains in the Lead, after this is melted out of the Ore. Therefore, whatſoever Quantity of Lead you may uſe for the Purifying of Silver from Copper, there remains always ſome minute Quantity of the Latter adherent to the Former: And as Copper is the more difficultly ſeparated from Silver by Lead, as the Proportion of the Copper with Regard to the Silver diminiſhes; for this Reaſon, a greater Exceſs of Lead

is required with Regard to this reſiduous Copper, than is neceſſary, even in the Lead itſelf, with Regard to the Copper mixt to it. He therefore who attempts the moſt intimate Depuration of Silver by coppelling, muſt previouſly render the Lead perfectly pure from all Copper: of which hereafter.

PROCESS IX.

To precipitate Silver out of its Ore, by coppelling alone.

APPARATUS.

1. Pound one Centner of the Ore; roaſt it (*Proc.* IV. N°. I.); when roaſted, beat it to a moſt ſubtil Powder; and, if it melts with Difficulty on the Fire, grind it together with one Centner of Litharge, which is not neceſſary, when the Ore melts eaſily. Then divide the Mixture, or the Powder of the Ore alone, into five or ſix Parts, and wrap up every one of them ſeverally, in ſuch Bits of Paper as can contain no more than this ſmall Portion.

2. Put a very large Coppel under the Muffle; Roaſt it well firſt, and then put into it ſixteen Centners of Lead: When the Lead begins to ſmoak and boil, put upon it one of the ſaid (N°. 1.) Portions with the ſmall Paper it was wrapt up in, and diminiſh the Fire immediately, in the ſame Manner as if you would make a Scorification in a Teſt, but in a leſſer Space of Time. The ſmall Paper, which turns preſently to Aſhes, goes off of itſelf, and does not ſenſibly increaſe the Maſs of the Scoria's: The Ore proceeding therefrom, is caſt on the Border, and turns to Scoria's very ſoon. Increaſe the Fire again immediately, and at the ſame Time put another Portion of the Ore into the Coppel, as was juſt now ſaid: The ſame Effects will be produced. Go on in the ſame Manner, till all the Portions are thrown in, and conſumed in the Lead. Finally, deſtroy the remaining Lead with a ſtronger Fire.

3. The Silver that was in the Ore and the Lead, will remain in the Coppel: If you take out of it the Bead proceeding from the Lead, you will have the Weight of the Silver contained in the Ore. If the Ore employed was eaſy to be melted, all the Scoria vaniſhes; but if it was refractory or not fuſible, all the Scoria does not always go away; but there remains now and then ſomething of it in the Form of Duſt. A great many Ores and Metals may be tried in this Manner, except only ſuch as ſplit and corrode the Coppels: There are likewiſe ſome of them, which muſt be previouſly prepared, in the ſame Manner as is required, to render them fit for going through a Scorification. See all the foregoing Proceſſes.

The Uſe and Reaſons of the Proceſs.

1. The Ore thrown at ſeveral Times upon Lead boiling in a Coppel, may be diſſolved without the foregoing Scorification. But this is very far from having an equal Succeſs with all Kinds of Ores: For there are Ores and Metals which reſiſt very much to their Diſſolution by Litharge; and which being on this Account thrown on the Border are not ſufficiently diſſolved; becauſe the Litharge ſteals ſoon away into the Coppel. Nevertheleſs, there are ſome others, which vaniſh intirely by this Method, except the Silver and Gold that was contained in them.

2. A previous Roaſting is neceſſary, firſt for the Reaſons mentioned (*Proc.* IV. *Uſ.* N°. 1.) and then becauſe the Ore thrown upon boiling Lead, ſhould not crackle and leap out: For, having once paſſed the Fire, it bears the moſt ſudden Heat.

3. Though this Method requires no previous Scorification, you are not to conclude from thence, that it is the ſame with the Operation by which Metallurgiſts ſeparate Silver from its Ores: For in theſe Caſes a Scorification is always previouſly made: For which

Reaſon theſe two Operations are not always attended with the ſame Effects.

PROCESS X.

The purifying of Silver by Lead, in a large Teſt, by the Blaſt of Bellows.

APPARATUS.

1. PUT into a large Teſt made in an earthen Pot (*Part* I. *Plat.* I. *Fig.* II.) and dried beforehand in a warm Place, red burning Coals, till it is thoroughly dry, and quite burning hot. Then make a Hole in the Hearth of the Smith's Forge, fit to receive the Pot with its Teſt, and fill it with Aſhes, to ſuch a Height as that the Border of the Teſt put into it may be as high as the Hearth of the Forge. Place the Pot in a horizontal Situation, and fill the Space between the Teſt and the Cavity of the Hole, with Aſhes well preſſed down, leſt they ſhould be eaſily blown away. Then diſpoſe the Noſel of the Bellows in ſuch a Manner, that, blowing obliquely downwards, it may play ſtrongly upon the Cavity of the Teſt: And this you will know to be well done, if the Wind proceeding from thence, diſſipates the Aſhes fallen into the Teſt.

2. Put into the hollow of the Teſt, ſo much Straw, Paper, Linen, or worn-out Cloth, as is neceſſary to hinder the Surface of it from being damaged by the Silver to be put into it: Put your Silver thereupon, and cover it well all over with red burning Coals: Then excite the Fire with the Bellows, till the Silver melts: This done, remove towards the Border the Coals hitherto kept in the Middle of the Teſt. Add next ſome new Wood and Coals, eſpecially towards the Bellows; and place the Coals all round in plenty, provided they do not intercept the Sight of the Maſs in Fuſion: And, mean while, continue to make a ſtrong Fire with the Blaſt of the Bellows.

3. Then add at ſeveral Times ſome Lead reduced into ſmall Globules of a determined Weight: The ſame Phenomena will appear, that were mentioned (*Proc.* II). Go on with adding ſome Lead, and then diminiſh the Fire a little, which muſt not be greater than is neceſſary to keep the Silver in Fuſion: Continue thus, till the Silver is rendered quite pure: Which may be gueſſed nearly, from the Examination previouſly made of its Purity or Impurity, by the Needle or by a docimaſtical Trial; and from the already-conſumed Quantity of Lead, that was judged neceſſary for the Purifying of it. However, you will be more ſure of this; if, the Lead being conſumed, you thruſt a moiſt Iron-Wire into the melted Silver, and look upon what adheres to it, the Inſtant it is fetched out, to ſee whether it is become yellow, or white, poliſhed, and malleable: If not, more Lead muſt be added. The melted Silver muſt be ſtirred ſometimes with a crooked Iron (*Part* I. *Plat.* IV. *Fig.* IX), towards the End; that the Lead, poſſibly adhering underneath, may be intirely conſumed.

4. The Operation being finiſhed, pour Water, Drop by Drop, or with a ſmall Stream, upon the melted Maſs; that the Silver may grow ſolid. When it is ſo, take it out of the Teſt with a Wedge, rub off all the Filth and Aſhes adherent to it, with a Braſs-Bruſh made of ſmall Braſs Wires collected into a ſmall Bundle, pouring in the mean Time conſtantly ſome Water upon the Silver.

The Uſe and Reaſons of the Proceſs.

1. Take Care in this Proceſs, that the Fire be not continued too ſtrong: For by that Means the Teſts grow ſoft, and a great Deal of the Silver is loſt. For the ſame Purpoſe, the Teſt muſt be put into the Pit, and ſurrounded on all Sides with Aſhes; whereby you hinder at the ſame Time the Pot that contains the Teſt, from ſplitting and falling down, and all the

Silver from being ſpilled, if the Teſt ſhould at the ſame Time contract a large Crack.

2. If you add the Lead at ſeveral Times, the purifying of the Silver may be peformed, with a much leſs Quantity of it, than that indicated in the eighth Proceſs. However, though, in this Operation, the Silver be found pure at Top; nevertheleſs, Part of the Lead, which is heavier, commonly hides itſelf underneath (*Proc.* II. *Uſ.* N°. 3), unleſs the Maſs in Fuſion be now and then ſtirred with a Piece of Iron, towards the End. But the ſame Inconvenience may be prevented in the ſmall Teſts or Coppels, if you ſtrike theſe little Veſſels with an Iron-Wire, while the Silver is ſtill in Fuſion, that this being melted may be ſhaken. Whence it plainly appears, that Silver and Lead mixt only by Fire, are not ſo well mixt to each other, as that a perfectly proportionable Quantity of both may be found in any Part of the Mixture whatever: Which, being either unknown to or neglected by Artificers, deceives them very often.

3. By this Method, a conſiderable Quantity of Silver may be purified at one and the ſame Time: But if a very refractory Scoria is produced, for Inſtance by a Mixtute of Tin, it muſt now and then be ſunk to the Bottom with a Poker, that the Silver may be waſhed off from it: And thus caſt on the Border of the Teſt. But it is proper afterwards to examine ſuch a Scoria, to ſee whether it has not carried away with it, a Quantity of Silver deſerving the Charges of a Separation.

4. The Lead may again be reduced out of the Teſts employed in this Operation; nay, this Lead is not even without ſome Silver; eſpecially if the Teſts were not good, or the Operations not exactly made: But then it will be proper again to uſe the ſame Lead for a like Operation; that the Silver may at laſt be ſeparated from it.

PROCESS XI.

The purifying of Silver in a large Teſt, under the Muffle.

APPARATUS.

1. PUT the Tin incloſed in an Iron-Ring (*Part* I. *Plat*. I. *Fig*. VIII), into the Furnace repreſented (*Part* I. *Plat*. IV), as you may very well underſtand, from the ſeveral Figures of the Furnace and from the Deſcription given of them. When the Teſt has been red-hot in a ſtrong Fire for about half an Hour; put into it the Silver wrapt up in Bits of Cloth or of Paper, and divided into ſeveral Portions: Fill the Orifice of the Furnace with red burning Coals, which muſt be kindled with a Pair of hand-Bellows, till the Silver is in Fuſion.

2. This done add ſome Lead; diminiſh the Fire a little: And do the reſt as has been preſcribed in the foregoing Proceſs.

The Uſe and Reaſons of the Proceſs.

1. The purifying of Silver is made in a much neater Manner, by this Method than by the foregoing: And as the Regimen of the Fire may be obſerved here with great Exactneſs, ſo the Silver is purified with a leſs conſiderable Loſs: For which Reaſon it is always preferred to the foregoing, when you are to purify Silver mixt with a great Deal of Copper: But it is a very long Operation.

2. When you are to purify only a few Ounces, of one ſingle Mark of Silver; you may put ſuch a ſmall *Apparatus* into the docimaſtical (*Part* I. *Plat*. III. *Fig*. I.) Furnace.

PROCESS XII.

A Method to ſelect Specimens out of Metals that have been refined, as well as out of thoſe that are melted together with Sulphur and Arſenick, that there may be the ſame Proportion of the Mixtures in the latter, as there is in the former.

WE have, in the foregoing Proceſs, explained in what Manner Silver, together with the Gold that lies hidden therein, may be ſeparated from foreign Bodies: But you cannot conclude otherwiſe than hypothetically from theſe Proceſſes, how much Silver and Gold may be fetched, out of a greater Quantity of the ſame Matter, from which you have taken your Specimen for the docimaſtical Trial: For Inſtance, whether there is the ſame Proportion of Ingredients in a ſeparate Specimen, as in the whole Maſs to be tried. But ſuch an equal Union is not always met with, in pure Metals confounded together by the Fire: Which we have ſeen plainly (*Proc.* X. *Uſ.* N°. 2); where Silver melted with Lead, and left to itſelf, was not evenly diſſolved by the Lead, but the ſame Portion of the Mixture contained more Silver at Top, and leſs underneath, and Lead in an inverted Proportion. The ſame Thing happens likewiſe with Gold and Lead, and with Copper and Lead: Unleſs you have Recourſe to ſome other manual Operation beſides the Fire, in order to obtain a more perfect Mixture. Beſides, it alſo depends much from the greater or leſs Degree of the Fire; which may increaſe, diminiſh, or totally diſturb, the Action of the *Menſtrua*. Nay, the Mixture of ſome Metals, for Inſtance of Gold, Silver, and Copper, which eaſily diſſolve each other equally, is ſo much troubled by the Addition of ſome other Metal, for Inſtance of Lead; that an equal Proportion of the Metals is no longer preſerved in every Part of the Maſs: For Gold and Silver, yielding more to Lead than to Copper, ſink to the Bottom in Company with it; ſo that the Mixture is much richer in Gold, Silver, and Lead there, than in the Middle, and at the upper Surface. But if Sulphur and Arſenick are joined to the Mixtures of Metals, they cannot but make a great Alteration there: For as they both diſſolve one Metal more greedily than another; they not only render the Mixture inequal, but ſometimes deſtroy it intirely: So that a Metal diſſolved by them, becoming lighter, it ſwims at Top like Scoria's, while the other Part of the Mixture ſinks towards the Bottom, by its Gravity.

APPARATUS.

1. When Ores groſly melted, are collected into brittle *Regulus's* in the Beds of the Furnaces, you are to proceed in the following Manner. With a Hammer and a Wedge, ſeparate from the *Regulus* two Pieces of equal Weight, for Inſtance of half an Ounce; that is, one in the Middle of the upper Surface, between the Centner and the Circumference; and the other in the inferior Surface of the *Regulus*, but on the oppoſite Side. Beat both to a fine Powder, of which weigh a Centner, and, as Sulphur, Arſenick, Iron, and a Portion of unmetallick Earth are not wanting therein, proceed according to *Proc.* IV.

But when you have a Mind to examine a greater Number of *Regulus's*, together in one and the ſame Trial, cut off Bits from each *Regulus*, in the Manner mentioned: you need only take Care, that the Weights of the Bits cut off be nearly proportioned to the Weights of the *Regulus's*: Beat them all into a fine Powder, and do the reſt as before.

2. But, when you are to examine *Regulus's* that are not brittle; Bits muſt likewiſe be cut off, in the Manner juſt (N°. 1.) mentioned: But, when cut, and weighed exactly, you muſt put them altogether into a new Crucible, well rubbed with Soap within, and melt them: When they are well melted, ſtir them

immediately with a dry Stick half-burnt; that they may all be well mixt together: Leave them ſo for about one Minute; then ſtir them again for the laſt Time, and throw into them a ſmall Bit of Paper folded up, and rubbed with Wax or Tallow: And while it burns with a clear Flame, pour the whole Maſs at one Stream into the Moulds (*Part* I. *Plat*. II. *Fig*. XX), placed quite horizontal, and rubbed with Tallow; and let this grow cold of itſelf, together with the Maſs therein contained. But the Maſs taken afterwards out of the Moulds, and commonly called *Ingot*, as is alſo the Cone itſelf (*Part* I. § 223), muſt be ſmooth, ſolid, and of an equal Thickneſs all round: But if it appears rough, and the Inſide of the Crucible (as far as the Maſs has touched it during the melting and the pouring out) is ſeen covered with a metallick Skin, it is a Sign that the Fire has been defective: And conſequently an equal Mixture has not been obtained. Beſides, a Fire too great and continued too long, produces a Scoria ſometimes ſolid, ſometimes ſpongy, full of Bubbles, covering the Maſs here and there when it has been poured out and cooled, or inſinuating itſelf deeper into it, while it is pouring out: If this be the Caſe, the Proceſs muſt be repeated. If the Maſs is in good Condition, ſcour it well with Coal-Duſt, and weigh it, to know how much of its Subſtance has been loſt. Then cut off from it a Bit, in the Place which is diſtant one quarter Part of the Length of the whole Maſs from each Extremity, in ſuch Manner however, that the Maſs may at the ſame Time be divided by a tranſverſal Section. This done, ſubſtract as much from the Centner or docimaſtical Mark, as all the Specimens cut off from the *Regulus's*, and weighed together before the Fuſion, have loſt of their Weight: Let the reſt go for an intire Centner or docimaſtical Mark, and with a File make the Specimen, which you have cut off from the Maſs of the Ingot, equal to it. However, take care not to ſcrape off any Thing from another Place, except from the two Surfaces which have been formed by the tranſverſal Section; eſpecially if there is any Lead in it. The Scorification is made as in *Proc.* III, but without Lead-Glaſs. Nevertheleſs, if an imperfect and refractory Scoria is produced, pour upon it a little of Lead-Glaſs, to ſubdue it. Let the remaining *Regulus* go through the Operation of coppelling, as in *Proc.* II. or, if there is any Copper, as in *Proc.* VI.

3. By theſe Precautions (N°. 1, 2) all the Silver and Gold remaining out of the Teſt, or reduced into the Form of Tables, may and ought to be cut off and prepared for a Trial: However, it is not always neceſſary to begin by a Scorification; unleſs Iron, Tin, &c. are mixt to the Maſs: We have already ſhewed the Manner of managing them.

4. When Coins are to be tried, you muſt cut off a ſmall Bit from them along your Diameter, and with a File reduce it to the Weight of the Mark, in the ſame Manner as the ſmall Bit cut off from the Maſs of the Ingot.

5. But when Coins of different Kinds, and old Utenſils, that have been coloured by having been boiled, are to be examined, the Thing is hardly done with more Eaſe and Security, than if all theſe Metals are granulated (*Part* I. § 216, 217.) together.

The Uſe and Reaſons of the Proceſs.

1. There is almoſt a greater Care required, in the Choice of theſe Specimens, than in the Operation itſelf, by which Gold and Silver are ſeparated from the other Minerals. Great Errors may be committed, when an Ingot is to be melted out of the ſmall Maſſes cut off. For Sulphur, Arſenick, Copper, Lead, and all the other Minerals, evaporate in Part, when the Fire is too ſtrong and two long kept, and partly turn to Scoria's, while the more fixt Part of the Silver and Gold remains: For this Reaſon, the Proportion which ought to have been preſerved in the remaining Ingot, it taken away: Whence it happens,

pens, that the Examination indicates a greater Quantity of Silver and Gold, than the Mixture out of which the Specimens have been taken, does in Reality contain. But this may be avoided, if you ſubſtract that Part, which the Specimens taken together have loſt in the Fire, from the Centner or docimaſtical Mark: That the remaining Part may be taken for the whole: Thus the Silver and Gold remaining after the Operation, will perfectly anſwer to the Quantity contained in the whole Maſs of the Mixture.

2. When Lead enters into the Mixture together with Copper, the Ingot ought never to be extinguiſhed with Water: For the Copper growing cold on a ſudden in Water, contracts, and repels the Lead ſtill in Fuſion towards the Outſide, and towards that Part of the Ingot which is immerſed the laſt into the Water. Likewiſe, the Ingot is always richer in Silver and Gold, in the Place where the Cone has been inclined towards the Horizon, than it is in the oppoſite Extremity: Which is eſpecially true of thoſe Mixtures, in which Lead and Copper enter together. The Reaſon of this is ſelf-evident, from what has been ſaid at the Beginning of this Proceſs. But the Copper muſt be tried before it is roaſted, to ſee whether it contains Silver, or Gold: For after that, their Separation is hardly worth the Charges (*Part* I. § 468, 469.)

3. Old Utenſils and Coins may be very well tried, if previouſly granulated. For when the Boiling happens to render them white, or when the Metal with which the Allay has been made, is not mixt in an even Manner, you are infallibly deceived. Now, they are rendered white by all ſuch Bodies, as corrode Copper the moiſt Way, and leave the Silver untouched. When ſuch Silver is allay'd with Copper, you muſt firſt wipe it very well, or make it ſlightly red in the Fire; that the fat Filthineſs may be diſſipated. Then put it into a Braſs-Kettle tinned over, and pour upon it enough of tartiſh Small-Beer, or of Water, that the

Silver may be intirely immerſed: Then throw into the Liquor a Quantity of Sea-Salt, and Tartar: Put the whole together upon the Fire, and make it boil: Thus will the Copper be eroded from the Surface in a few Hours, and the Silver remain alone. Therefore, though you had put the moſt poliſhed Lamina into the Fire, you will take it out quite deſtitute of Brightneſs, but of the whiteſt Colour. Then waſh it with Small-Beer, and rub the Surface of the Silver, with Bruſhes made of thin Braſs-Wires. But if this Surface is again rubbed with a ſmooth Piece of Steel, it recovers its former Poliſhing. It is here neceſſary to know this deceitful Colour, not only when you uſe the (*Part* I. § 300.) Touch-ſtone, but alſo in a docimaſtical Trial: For when the Specimen taken off from ſuch Silver, is thin, or of a large Surface, it leaves more Silver in the Coppel, than if you cut from that Silver a ſmall Bit of the ſame Weight, in a Place where a leſſer Surface has been contiguous to the corroding Solution.

PROCESS XIII.

The waſhing (Part I. § 337, 479.) *of an Ore, rendered difficult to be melted, by Earths and Stones.*

APPARATUS.

1. BREAK your Ore in an Iron-Mortar, to a Powder not very fine: Weigh twenty or thirty docimaſtical Centners of it, in a large Balance: Put them into a waſhing Trough (*Part* I. *Plat.* II. *Fig.* XVI.) pour ſome Water upon them, that the Powder of the Ore may be thoroughly moiſt: Then have a Veſſel full of Water, the Diameter of which muſt be a little larger than the Length of the Trough: Take the Trough with your left-Hand, at the Top of the hinder-Part, and dip it horizontally into the Water, and move it gently with your right-Hand, from the fore-Part of the Trough, which is leſs deep,

towards the hinder Part, which is deeper: Then take out the Trough, and incline it a little on the fore-Part; that the Water may run out, and the heavier metallick Part remain at the Bottom: Repeat this ſeveral Times over, till the Ore remains quite pure.

2. If the Ore is inherent to a very hard Stone hardly yielding to Iron, ſuch as are Flints, and the other Stones of that Kind, or to a ponderous, calcareous, Spaad-like Stone; it muſt firſt be weighed, and then be made quite red-hot in a Crucible, and in this Condition be thrown into a Veſſel full of cold Water, and after that be pounded very fine and waſhed very clean.

3. When the Ore is waſhed, weigh it, and try one Centner of it: that is, according as the Nature of the Ore requires it. Thus you will eaſily compute, how much Silver or Gold, you will be able to obtain from twenty Centners of Ore.

The Uſe and Reaſons of the Proceſs.

1. From what has been juſt ſaid, and from what was ſaid (*Part* I. § 338) it appears, that every Ore will not bear waſhing; it ſhews likewiſe what kind of waſhing each Ore will require; and what Ores can be waſhed without a Preparation: Of this laſt Kind are thoſe which conſiſt of ſolid pure Particles, and lie hidden in a ſoft fat kind of Earth, or in Sand. Thence, you likewiſe ſee, in what Manner they muſt be previouſly pounded, or calcined (Compare *Part* I. § 337). By Calcination, you not only break Stones into Pieces with greater Facility, but Ores beſides melt into ſolider Maſſes, which moſt commonly are ſpecifically heavier, on account of the Sulphur and Arſenick in a Manner diſperſed through them.

2. The Intention of waſhing is, to render the Ore more tractable in the Fire; and to hinder the metallick Parts from being difficultly precipitated, or even totally detained by ſo great a Maſs of Scoria's,

and that a much greater Quantity of Ore may be fluxed in the ſame Fire, and in the ſame Time.

3. But the lighteſt Powder waſhed off, muſt ſometimes be tried: For it now and then happens, that the Water carries away a greater Quantity of Ore, than there remains of it in the Bottom of the Veſſel: In which the moſt experienced People are oftentimes deceived. Nay, the Waters which run by Veins of Ores, commonly enough carry Part of them away, and after having dragged it a long Way together with them, at laſt let it fall at the Bottom of the Channel. As for the reſt, ſee *G. Agric. de re Met.* Lib. VIII.

PROCESS XIV.

The purifying of Silver with Nitre.

APPARATUS.

1. REduce your Silver to Grains, or Plates; put them into a Crucible: Add about one quarter Part of the drieſt Nitre pulverized. Put upon this Crucible another of a leſſer Size, having at its Bottom a Hole about as large as a Pea, in an inverted Situation, that the Border of it may be received into the Orifice of the other. Shut up the Joint of the two Crucibles, with a Lute that may bear the Fire: And when this is dry, put the Crucibles in a wind-Furnace, and ſurround them with Charcoals, to the Height of the Bottom of the upper Crucible, and not further.

2. Then light the Fire at Top, and increaſe it till the Veſſels are middling red-hot. Then with a Pair of Tongs take a burning Coal, and hold it at one Finger's diſtance directly above the Hole at the Bottom of the upper Crucible: If you ſee a ſudden clear Light produced near and about the Coal, together with a crackling Noiſe, this ſhews that the Fire has actually the requiſite Degree of Strength: But if this either does not appear at all, or only very faintly,

the Fire muſt be increaſed. If, on the contrary, you hear a violent Blaſt of Air, coming forth with a loud crackling Noiſe, though you have not put the above-mentioned Coal at Top, the Fire is too violent, and muſt of courſe be diminiſhed. Which being neglected, you will not only ſuffer a great Loſs of Silver; but large Veſſels, charged with a great Quantity of Nitre, now and then burſt aſunder with Violence and Danger.

3. When this Phenomenon is over, increaſe the Fire as much as is neceſſary to make the Silver melt without any Addition: Take the Veſſels out of the Fire: Break the under one, when it is grown cold: You will find the *Regulus* of Silver at Bottom, and alkaline Scoria's (commonly green) at Top. If the Silver is not yet ſufficiently purified, or too rigid ſtill, put it into another Crucible, and this thus open into a wind-Furnace, throw upon it a little Nitre, and as ſoon as it melts, pour it into a Mould for Ingots: Thus it will be purified of every thing that's not Gold.

The Uſe and Reaſons of the Proceſs.

1. We have already conſidered (*Part* I. § 137, 161.) the Action of Nitre upon Metals and Semi-Metals. Therefore, if you operate in a due Manner, Silver is, by this Method, rendered perfectly pure and eaſy to be bent. But if your Silver is very impure, a ſmall Matter of it is deſtroyed in this Operation; which muſt be aſcribed to the ſtrong Detonation of Nitre with other Metals, and to the Clammineſs of the Scoria's made by their Calxs.

2. The Nitre in this Proceſs ſeems partly to become volatile, and partly to change into a fixt Alkali, ſo very pure, that there remains not the leaſt Footſtep of Nitre: For when you pour upon it Oil of Vitriol, it does not in the leaſt excite the unpleaſant Smell of *Aqua Fortis*, which nevertheleſs is commonly produced, when you prepare fixt Nitre in the uſual

Manner: The Reaſon of this Diverſity is, that they do not imploy a Fire ſufficiently ſtrong, to conſume or diſſipate all Sorts of Nitre.

3. Silver thus purified for the firſt Time, has always in it a ſmall Quantity of heterogeneous Metal: But if you melt it a ſecond Time (N°. 3.) with Nitre, and pour it out, the Moment it is in Fuſion, you free it of that Reſidue, and render it very eaſy to be bent. But your Silver will not acquire ſo great a Degree of Purity and Pliantneſs, unleſs you pour it out the very Inſtant it is in Fuſion. For the Nitre, when left too long in the Fire, diſſipates, or changes: And when this happens, the Metals calcined by the Nitre, though in ever ſo ſmall a Quantity, are reduced by the fat Exhalations of the Coals, and much more ſtill when the Coals themſelves fall into them: Nor is the reſiduous alkaline Salt an Obſtacle, but rather a Help to this. And as Gold, above all, is rendered very rigid, or even quite brittle, by the leaſt Quantity of Tin, Regulus of Antimony, &c. the Reaſon is plain, why unſkilful Artificers, try ten Times and more, to render Gold pliant by Means of Nitre, before they can obtain it.

PROCESS V.

Precipitation of Silver out of the ſame Bodies as were mentioned in the foregoing Proceſſes by Scorification, in a Crucible.

APPARATUS.

1. THE Body out of which you intend to precipitate Silver, muſt be previouſly prepared for a Scorification with its proper Ingredients; of which we have already ſpoken in the foregoing Proceſs; then in the ſame Manner, and with the ſame Quantity of granulated Lead, put it into a Crucible ſtrictly examined, that it be intire, ſolid, not ſpeckled with black Spots, like the Scoria of Iron, eſpecially at its

inferior Part, and capable of containing three Times as much. Add beſides Glaſs-Gall and common Salt, both very dry, and enough that, when the whole is melted, the Salts may ſwim at Top, at the Height of about half an Inch.

2. Put the Crucible thus loaded into a Wind-Furnace; ſhut it cloſe with a Tile; put Coals round it, but not higher than the upper-Border of the Crucible: Then light them with burning Coals, and increaſe the Fire till the whole melts very thin: Which will be done by a middling Fire, maintained always equal, and never greater; leave it thus for about one Quarter of an Hour, that the Scorification may be perfectly made: Take off the Tile, and ſtir the Maſs with an Iron-Wire, and a little after pour it out into the Mould.

3. When the Regulus is cleaned from Scoria's, try it in a Teſt by coppelling it.

The Uſe and Reaſons of the Proceſs.

1. The Scorification of any Ore whatever, or of any other Body fetched out of Ores, may indeed be made by this *Apparatus*, as well as in a Teſt under the Muffle: But it ſerves chiefly, to the End that a greater Quantity of Metal may ſometimes be melted from it with Profit: For you may put many common Pounds of it, at one ſingle Time into the Crucible: But then you need not obſerve the Proportion of Lead preſcribed in the foregoing Proceſs, nay, a Quantity of Lead two or three Times leſs, is ſufficient according to the different Qualities of the Object. But the Maſs will certainly be ſpilt, unleſs you chuſe a very good Crucible. For there is no Veſſel charged with Litharge, that can bear a ſtrong Fire having a Draught of Wind, without giving Way through it to the Litharge.

2. You add Glaſs-Gall and common Salt, that they may forward the Scorification, by ſwimming at Top. For the refractory Scoria rejected by the Litharge, and

[illegible] difference between this and the Scoria that form [illegible] and the Precipitation [illegible]. They also in a Manner [illegible] Glass, fallen into the [illegible], which [illegible]. For the Litharge or Glass of Lead, [illegible] without any [illegible], as soon as the Phlogiston gets into it, [illegible] a Mass, consisting of a Multitude of small Bubbles, very difficult to be confined, unless the Phlogiston be entirely consumed, and the Litharge reduced to Lead, which sometimes rises above the Border of the Vessel.

PROCESS XVI.

Precipitation by Iron and Lead, of Silver out of a Mixture consisting of [illegible] of Sulphur.

APPARATUS.

THIS may be done in the same Manner as in the foregoing Process, but much better after the Manner following.

1. If you do not know already, how much Silver lies hidden in the Mixture, you must, for that Purpose, make a Trial, according to the first, the second, or the third Process. This done, let the Mixture be melted in a Wind-Furnace on a middling Fire, in a Crucible, having a Capacity two or three Times larger. Then cast upon it at several Times, Iron-Filings, not very rusty, and being one third Part with regard to the Weight of the Silver: In the mean Time increase the Fire: When you see the Iron-Filings quite dissolved by the Sulphur, and melted, pour thereupon an equal Weight of granulated Lead regard to the Silver, in such a Manner, however, it may be dispersed all over the whole apparent Sur- of the melted Mixture: Then stir it with an Iron- , that all these Things may be thoroughly mixt.

2. Shut the Crucible very cloſe: Increaſe the Fire ſtill more: and after having kept it ſo for about half a Quarter of an Hour, pour the Maſs out into a melting Cone, rubbed with Tallow, and warmed, or into an Iron-Mortar, prepared after the ſame Manner.

3. When it is grown cold, ſtrike the Matter out: You will find at Top Scoriæ in [illegible], and at Bottom a *Regulus*, that will have all the Silver in it, together with the Lead, or at leaſt with Part of it. The *Regulus* may be cupelled on a Teſt.

4. If you know that there is already the ſame Quantity of Lead in the Mixture, it is not neceſſary to add any granulated Lead: but rather to double the Weight of the Iron-Filings.

The Uſe and Reaſon of the Proceſs.

1. All that was ſaid (Part I. § [illegible]. Coroll. 1. 2.) is very well and [illegible]. But you muſt add Lead towards the End; that the Silver which is perhaps ſtill inherent in the Mixture, being quicker diſſolved by the Lead, may be precipitated, and ſink to the Bottom; or that the Sulphur may be intirely taken away by the Lead (*i. e.*, if it has not been thoroughly deſtroyed by the Iron. There are alſo ſome other Metals, that have the ſame Effect; but Lead is choſen in this Caſe, becauſe it is very conveniently ſeparated a ſecond Time from the Silver: For there is always ſomething of the precipitating Metal, that mixes with the Metal to be precipitated; the more ſo, as the Separation is more exactly done: For who can ſo exactly determine the Point of Saturation, and the Degree of the Fire?

2. You muſt not uſe Filings quite ſpoiled with Ruſt: For they have no Virtue for abſorbing the Sulphur.

3. The Crucibles, which have ſerved to theſe Proceſſes, retain a little of the Silver, eſpecially if they are rough at the Inſide: For this Reaſon, the ſame Crucible, ſo long as it remains intire, muſt always

ſerve for the ſame Operation. But when it breaks to Pieces at laſt, and the Bits are plunged into the boiling Lead, all the Silver is ſeparated from it: Which Lead muſt ſerve for the like Operations, as well as that which is reduced out of larger Teſts: Thus all the precious Metal is preſerved.

PROCESS XVII.

The extracting of Silver, by Amalgamation.

APPARATUS.

1. WASH the Ores, Earths, Stones, and Sand, in which Silver lies hidden in its metallick Form, according to *Proc.* XIII. When waſhed, infuſe them in very ſour Vinegar, in a wooden or Glaſs-Veſſel perfectly clean: But about a tenth Part of Allum muſt be firſt boiled and diſſolved in this Vinegar, that the waſhed Powder may be intirely covered over: Leave them thus for one or two Days and Nights.

2. Decant the Vinegar, and waſh the macerated Powder in pure warm Water; till the Water becomes quite inſipid, when juſt poured upon it: Dry the Powder; put it into an Iron-Mortar: Then add Mercury four Times the Quantity of the dried Powder, and with a wooden Peſtle, ending in a large round Head, and adapted to the Inſide of the Mortar by its Figure and Size, beat the whole, till you ſee every little Part of the Powder rendered of a blackiſh Colour by the minute Globules of Mercury mixt to it.

3. Then pour Water thereon, and continue the Trituration for a While: becauſe you thus will waſh away the terreſtrial Powder and the other heterogeneous Bodies remaining, and becauſe all the Globules of the Mercury, will by that Means be aggregated to the Silver and Gold. Pour out the turbid Water, and add ſome freſh; then grind the whole again,

till all the remaining Powder be waſhed off at laſt. Then dry the remaining Amalgama with a Spunge, and by a gentle Heat.

The Uſe and Reaſons of the Proceſs.

1. Amalgamation is chiefly uſed, when Silver lies hidden in its metallick Form in Stones, Earths, and Sand. But when it is in a State of Ore, the Bodies that concur with it to form the Ore, muſt be diſſipated (*Part* I. § 463): Otherwiſe, the Amalgamation would not ſucceed. Therefore a previous Waſhing muſt be made, that the other Bodies which cannot be diſſolved by the Mercury, may be waſhed off as much as poſſible: For, unleſs this be done, the Mercury cannot act freely upon the Silver: Nay, if the Waſhing is done afterwards, a great Deal of the Mercury is waſhed off together with theſe heterogeneous Bodies. For which Reaſon, likewiſe, the Ore is ſoak'd in Vinegar prepared with Allum, that the terreſtrial duſty Bodies, or even the fat Ones, may be wiped off the Surface of the Silver. As for the reſt, ſee *Part* I. § 65. *and following*. For this Reaſon, the Mercury ſometimes refuſes to diſſolve the Silver: Which nevertheleſs is corrected, if the Mercury is rubbed with common Salt and Water, and afterwards waſhed very clean.

2. If you continue to grind the Amalgama with Water, longer than till you ſee no more Filth in it; the Water poured upon it will nevertheleſs be always turbid, and you will loſe Part of your Amalgama.

3. They make a particular kind of Mills, in which a great Quantity of Amalgamations are made, and which are well deſcribed by *G. Agricola, de re Met.* Lib. VIII.

PROCESS XVIII.

The Separation of Silver from the Amalgama.

APPARATUS.

1. SPread a thin Leather upon a wide earthen or Glaſs-Veſſel, very clean: Fold it up in the Form of a Bag, and pour the Amalgama into it: Then tie the Bag very ſtrongly at Top, that the empty Spaces of the Plaits may not give Paſſage to any Part of the Mercury. This done, if you compreſs the Bag by wringing it hard, the major Part of the Mercury will paſs through it, and run into the Veſſel under it. If you can no longer ſqueeze any Thing out, open the Bag, and you will find in it a white Paſte, which ſhall be the Silver and the Gold that were in the waſht Powder: But there remains about an equal Quantity of Mercury ſtill mixt with them after the Squeezing.

2. Put the remaining Paſte into a Glaſs Retort; and this into an Iron-Pot full of Sand (*Plat.* IV. *Fig.* I.): Apply to it a Recipient, in which there muſt be ſuch a Quantity of Water, as that the Orifice of the Neck of the Retort may be immerſed into it: Nor is it neceſſary to cloſe the Joints with Lute. Make under this a ſtrong Fire, till you ſee the Mercury applying itſelf by large Drops to the Neck of the Retort, and falling into the Water, with a hiſſing Noiſe: But if you hear a Crackling in the Retort, then diminiſh the Fire a little; and if at laſt nothing more is diſtilled by the great Fire, let the Retort grow cool, then take it away, and ſplit it with a Thread dipped in Brimſtone, which for this Purpoſe muſt be tied about the Middle of the Belly of the Retort, and ſet on Fire: Then in the Fire with Borax run the remaining Metal into a Maſs.

The Uſe and Reaſons of the Proceſs.

1. As Mercury requires a Fire three Times ſtronger, to be volatilized, than Water does; ſo when it is reſolved into Fumes, it coagulates immediately, if touched by Water; nor are you to be apprehenſive leſt the leaſt Quantity of it ſhould evaporate in open Veſſels, provided the Orifice of the diſtillatory Veſſel is immerſed under the Water. You are only to take Care not to immerge it too deep: For in this Caſe, not only the Neck of the Retort ſplits eaſily, but, when the Degree of the Fire is very great at firſt, and afterwards leſs, the Water aſcends through the Neck of the Retort, and falls into the Belly of it, which, on this Account, ſplits when it is hot; and thus the Operation is deſtroyed. But when the Neck of the Retort is not immerged, the Joints muſt in this Caſe be cloſed with Lute: But if you imploy then too great a Fire, the Veſſels burſt violently aſunder, with ſome Danger, becauſe of the pernicious Fume. Beſides, when your Fire is too ſtrong, Part of the Silver eaſily gets into the Recipient together with the Mercury.

2. If, for Want of an *Apparatus* for Scorification and Coppelling, you have a Mind to indicate by this Method, the Quantity of Silver contained in the Body waſhed; in this Caſe, the whole Amalgama muſt be diſtilled through the Retort; becauſe Part of the Silver and gold gets through the Leather: Nay, there remains nothing at all of the Silver or Gold within the Leather, if you uſe too great a Quantity of Mercury, to extract a ſmall Quantity of theſe Metals: Unleſs the Mercury be ſaturated with them, by a like previous Proceſs; and even then, you may be eaſily deceived as to the Quantity and Quality of the Metal.

PRO-

PROCESS XIX.

To render Silver very pure, by Precipitation out of Aqua Fortis, *with Spirit of Salt.*

APPARATUS.

1. WHEN Silver has been coppelled, diſſolve it with *Aqua Fortis*, in a very clean Glaſs-Cucurbite: And if the Solution is the leaſt in the World turbid, ſtrain it through a double filtring Paper, into another clean Glaſs-Veſſel. Pour into this Solution, by little and little, Spirit of Salt, or Solution of common Salt, or Salt Ammoniack, enough to produce a perfect *Aqua Regis (Part* I. § 128. *&c.)*: The limpid Diſſolution will immediately become milky: Let it reſt for ſome Hours, that the Silver extracted in Form of a white Powder, may all ſink to the Bottom: Which is ſooner effected, by pouring a great Quantity of pure Water upon the Solution, if it be highly charged. This done, decant gently the Liquor at Top. But, you muſt pour upon the Calx adherent to the Bottom, freſh Water, or, what is ſtill better, Phlegm of Spirit of Salt, or of *Aqua Fortis*; that all the Metal may be extracted out of it: For the Calx is no longer diſſolved in *Aqua Fortis*, nor in Spirit of Salt. Finally, let it boil at ſeveral Times in freſh Water, till the Calx and Water are at laſt perfectly inſipid. Shake them together, and pour them into a filtring Paper, that the Water may go through it; and then dry the Calx.

2. Put it into a Crucible, well rubbed on the Inſide with Soap, and cover it with about one Half of any fixt alkaline Salt, very dry, and beaten to a very fine Duſt: Squeeze the Whole well with your Finger: Cover the Crucible with a Tile, and put it in a Wind-Furnace, and make at firſt a middling Fire for a Quarter of an Hour, only to make the Veſſels grow

red-hot; and then increaſe it as much as is required for a perfect Fuſion of the Silver and Salt. The Fuſion being obtained, take out the Crucible, that the whole may cool of itſelf; or pour it into an Ingot; the Silver ſhall be reduced perfectly pure out of this Calx.

3. If this Silver-Calx (N°. 1.) is expoſed alone to the Fire, it melts ſo ſoon as it grows red; and if you then increaſe the Fire a little more, it vaniſhes in Fume; when poured out quickly, it appears a Body of a light ſcarlet Colour, half-tranſparent, ponderous enough, and ſo tenacious, that it is difficult to reduce it to Powder, and if you break it, it ſeems to be of a fibrous Texture within: Whence it is called *Lunæ Cornua*, on account of its reſembling the Horns of Animals on the Outſide.

The Uſe and Reaſons of the Proceſs.

1. Silver is not to be diſſolved the moiſt Way in *Aqua Regis* and Spirit of Salt; on the contrary, when it is already diſſolved in *Aqua Fortis*, you precipitate it thence with Spirit of Salt: But ſo ſoon as this is done, a Solution of the Silver by the Acid of *Aqua Regis* happens in the dry Way: For a conſiderable Quantity of *Aqua Regis* is joined to the Calx of Silver precipitated to the Bottom; whence its Volatility depends. For this Reaſon likewiſe, if you mix a little of Spirit of Salt to Spirit of Nitre, you eaſily obtain the Separation of the former from the latter by Silver. See *Part* I. § 122. But the Copper whereof any ſmall Quantity remains mixt with the Silver, in the Operation of coppelling, is not to be precipitated by Spirit of Salt: Therefore, when the other Metals are conſumed in the Coppel, the metallick Part of this Calx is perfect and pure Silver. Gold itſelf is alſo perfectly ſeparated in the ſame Manner, if the *Aqua Fortis* it not quite ſaturated by the Silver.

2. The Spirits muſt be pure, and the Calx perfectly well waſhed: Otherwiſe you will not always purify your Silver.

3. This *Lunæ Cornua*, muſt be reduced the dry Way, that is, by whatever abſorbs *Aqua Regis* with great Force. Therefore you ſee this Property in ſome Metals, for Inſtance, in Lead, Tin, and all the alkaline fixt Salts. But the Silver is ſpoiled anew by the two former, and a great Quantity of it is deſtroyed at the ſame Time: Which may be gueſſed from the thick Smoak, which is produced in a violent Reduction made after this Manner. But all your Silver is preſerved by a fixt Alkaly, provided you uſe a proper Courſe.

4. If you pour into the firſt Liquor remaining from the Precipitation, and decanted, a fixt alkaline Liquor, or a volatile urinous concentrated Spirit, in ſuch Quantity as ſhall greatly exceed the exact Point of Saturation: The Colour of both, which was hardly ſenſible before, turns to a deep Azure, which muſt be owing to the Preſence of Copper: For when this is in a ſmall Quantity, it diſſolves the moiſt Way in alkaline Salts, and then produces this Colour. The downy whitiſh Powder which is produced during this Mixture, and at firſt ſwims like Flocks of Wool, and then ſinks to the Bottom, is not Copper, but proceeds from the Earth, which is produced in every Regeneration of neutral Salts, and to which the ſmall Quantity of Gold, which poſſibly was in the Silver, is mixt.

PROCESS XX.

To extract Gold out of its Matrixs.

APPARATUS.

ALL the Proceſſes by which Silver is got out of the Ores in which it lies hidden, and is ſeparated from foreign Bodies, from *Proc.* I. to XVIII. belong to this Article. For Gold, as well as Silver, is free from the Action of Lead and Glaſs of Lead, and ſuſtains the Coppel and the Teſt, in which all the other Bodies turn to Scoria's. Therefore, Gold mixt with Silver is collected in the very ſame Proceſs by which the ſaid Silver is ſeparated from its Ores: as we have already mentioned ſeveral Times, in the foregoing Chapters. Amalgamation itſelf is more proper to Gold than to Silver; that is, as they are both ſeparated from their Matrixs by this Operation: For there is no Metal, that is not more frequently met with in a State of Ore, than in its metallick State: But Gold is always found in a true metallick State; unleſs its Quantity is many Times inferior to that of the Silver adherent together with it in the ſame Matrix. But Gold, even in this Caſe, cannot always be ſaid to be in a State of Ore (See *Part* I. § 400). Now, a true metallick State is required for an Amalgamation; becauſe no Extraction can otherwiſe be made by Mercury.

There is indeed a great many Proceſſes recommended by ſeveral Artificers, for the extracting of Gold out of its Matrix; and by which they ſay that you will obtain more than by the ordinary Method: But they, for the moſt Part, are ſo trifling and ſo tedious in the Work, that they hardly deſerve to be deſcribed, ſo far they are from being worthy to be imitated. The moſt common of them are thoſe, in which the Ore is prepared by roaſting; which muſt not be always neglected; as it is ſometimes altogether neceſſary. But to repeat it ſo many Times over, to extinguiſh the Ore after each roaſting in Urine of Children, or in other Lies prepared in a particular Manner, then to ſcorify it firſt in a Crucible with Lead and other Ingredients, and afterwards to put it in a Teſt to ſcorify it a ſecond Time, and ſo on, is a Method as ſilly as it is toilſome; by which Gold is rather diſſipated than it is collected.

W[illegible] then nothing to do here concerning Gold, but [illegible] the Methods by which Gold is ſeparated [illegible] and thoſe by which it is ſeparated from [illegible]etals: as far as theſe Methods differ from thoſe which we have already given, for the Separation of Silver from other Metals.

PROCESS XXI.

To render [illegible] *from Silver, by Aqua* [illegible]

[illegible]*AR*[illegible]*TUS.*

1. THE[illegible] and Silver, muſt firſt be [illegible]g to *Proc.* II. or VIII. with a ſufficie[illegible] Lead, that the other Metals may b[illegible] which a little more Lead is preferable to a leſſer Quantity. Out of the remaining *Regulus* forge thin Plates; and whenever the Metal grows rigid under the Hammer, make it red-hot in a gentle pure Fire, whereby its Ductility will again be reſtored.

2. When the ſaid Plates are ſufficiently thin, make them red-hot for the laſt Time, and cut them into ſmall Bits with a Pair of Sheers, and then keep them in a warm Place, in a Cucurbite made of tranſparent Glaſs, pouring upon them a ſufficient Quantity of the pureſt *Aqua Regis*, which muſt be ſtrong enough. In the mean Time, let the Orifice of the Cucurbite be ſhut cloſe with a Cornet of Paper, to prevent any Duſt from falling in.

3. The Diſſolution being finiſhed, pour out ſoftly the ſupernatant Fluid into a wide open Glaſs-Veſſel; taking Care that the leaſt Part of the Silver, adherent to the Bottom in Form of a white Powder, does not go out along with it. Pour upon this remaining Calx ſome Phlegm of Spirit of Salt, and make it boil with it a while, that the reſiduous Diſſolution of Gold may [illegible] waſhed off, and added to the firſt by decanting. This

done, inſpiſſate the Liquors over a gentle Fire, till they are dry: Put what remains into a Crucible, and cover it with Powder of Borax, melted before-hand with a little Nitre: Cover the Crucible cloſe with a Tile; and make the Melting firſt with a gentle, and a little after with a great Fire. Then pour it into a Mould to have an Ingot.

The remaining Calx of Silver being waſhed out of the Cucurbite, by pouring Water upon it, may in a wide Veſſel be decanted, and being dried by Fire, may be melted in the ſame Manner.

The Uſe and Reaſons of the Proceſs.

1. All the Metals that are diſſolved in *Aqua Regis*, muſt be conſumed by Coppelling, before the Diſſolution; leſt, being diſſolved together with the Gold, and inſpiſſated, they be again confounded with it: But the ſmall Quantity of Copper remaining after the Coppelling (*Proc.* VIII. *Uſ.* N°. 2), being much divided by that Degree of Fire which puts Gold in Fuſion, is deſtroyed partly by itſelf, partly by the Nitre, and turns to Glaſs, and is received by the Salts.

2. Gold may be precipitated quicker out of its Diſſolution, by a fixt or volatile Alkali: But the Calx proceeding therefrom, which is of a dark yellow Colour, being dried on a gentle Fire, becomes that kind of Gold called *Aurum Fulminans*, becauſe, when the Heat is not increaſed too ſuddenly, but only by Degrees, it decrepitates with great Violence, and with a thundering Noiſe, and ſcatters every Thing round it with ſuch a Force as was hitherto never obſerved in any other Body. We ſhall ſoon teach, how this ought to be reduced, or rather ſeparated from the Salts, which produce this thundering Noiſe together with it.

PROCESS XXII.

To ſeparate Gold from Silver with Aqua Fortis.

APPARATUS.

1. AS *Aqua Fortis* cannot corrode Silver off from Gold, unleſs the former be three Times in greater Quantity than the latter (*Part* I. § 472); it is not every Mixture of Gold and Silver than can be ſeparated by *Aqua Fortis*. Let therefore the Mixture of the white Allay be purified in a Coppel from the other Metals, if there is any in it; and be tried with the Needles (*Part* I. § 295). If the Allay of it is ſuch, that it contains ſix Carats or leſs of Gold, and eighteen or more of Silver; you may reckon it fit to make a Separation with *Aqua Fortis:* If not, you muſt either add a ſufficient Quantity of Silver by melting together in the Fire, or make the Separation with *Aqua Regis*, according to the foregoing Proceſs.

2. Now, if the Mixture is ſo allayed, as to admit of the Action of *Aqua Fortis*; reduce it to ſmall Plates; put it into a ſmall Cucurbite, and pour upon it a double Quantity of *Aqua Fortis*, of a proper Strength, and tried, that the leaſt Quantity of Silver may not be precipitated out of it (*Part.* I. § 121, 122); then put it in a warm Place, with a proper Cover. If the Bubbles and red Smoak, which are produced during the Diſſolution, make you think that the Silver is corroded, decant the Solution, while it is yet warm, into another Glaſs-Veſſel, and pour upon what remains freſh *Aqua Fortis*, but in Quantity twice as little as the firſt Time: Expoſe it again to the Fire, to make it boil; then decant it again warm, and repeat this once more; then waſh the Reſidue with freſh Water; which will be your Gold, of a dark Colour, light, ſpungy, and brittle, out of which the Silver is corroded.

3. You may pour it out, in the ſame Manner as you have done the remaining Calx of Silver, in the foregoing Proceſs (N°. 3). But the firſt Diſſolution, being ſaturated, muſt either be drawn off (*Part* I. § 125) to ſeparate from it the Silver, which will then be perfectly pure, or it muſt be diluted with Water: Put into it very clean thin Copper Plates, and immediately the Silver will firſt cover the Copper all over, under the Form of very thin and ſmall Leaves, and then by Degrees be precipitated to the Bottom, and the Solution, which was before deſtitute of Colour, ſhall be tinged with a greeniſh azure Colour: Pour this together with the Calx into an edulcorating Veſſel (*Part* I. *Plat*. II. *Fig*. XIII) and expoſe it a while to a Fire almoſt ſtrong enough to make it boil: Thus all the Silver will at laſt be diſengaged: Decant the Solution of Copper from the lighter Silver-Duſt ſubſiding, and pour upon it at ſeveral times Water, which muſt boil till it becomes perfectly inſipid. Finally, let the dulcified Calx of the Silver be meletd together with Borax, firſt by a gentle Heat, and then by a ſtrong Fire. But this Silver will not be perfectly free from Copper.

The Uſe and Reaſons of the Proceſs.

See on this Point (*Part* I. § 472. and the foregoing Proceſs) and obſerve moreover, that, unleſs you pour out the Solution of Silver warm, ſome Cryſtals of Silver will be produced, very difficult to be diſſolved, which ſurround the Remainder of the Gold in ſuch Manner, that the Silver, remaining to be corroded off from the Gold with recent *Aqua Fortis*, is very difficult to be diſſolved.

PROCESS XXIII.

The Silver remaining (Proc. XXI. N°. 3.) *retains ſomething of Gold in it; and the Gold remaining* (Proc. XXII. N°. 2.) *ſomething of Silver.*

APPARATUS.

1. IF the Silver which (*Proc.* XXI. N°. 3.) remains under the Form of a white Calx, is diſſolved in the pureſt *Aqua Fortis*, there will remain at Bottom a ſmall Quantity of a Powder not diſſolved, and of a dark Colour; but the Part of it which melts into a *Regulus* and proves to be Gold is extreamly ſmall.

2. If the Gold out of which Silver has been corroded by *Aqua Fortis* (*Proc.* XXII.) is diſſolved in *Aqua Regis* according to *Proc.* XXI, it leaves at the Bottom of the Veſſel a ſmall Quantity of white Silver Calx, which the *Aqua Fortis* had not corroded from the Gold.

The Uſe and Reaſons of the Proceſs.

1. Every Thing is plain in the two foregoing Proceſſes: But, the *Aqua Fortis* or *Aqua Regis* are more or leſs pure, and of a proper Strength, according as they are more or leſs frequently poured recent upon the Mixture, and left to act a due Time upon the remaining Metal with a ſufficient Heat. In ſhort, the greater or leſſer the Thickneſs of the ſmall Plates of Silver and Gold is, and their Surface rendered more or leſs clean by the Fire; the more or leſs of the Metal, to be corroded by a proper corroſive Water, remains undiſſolved in the Reſidue of the Mixture.

2. If, therefore, you would have either of theſe Metals perfectly pure; this muſt be corroded off from the other by its *Menſtruum:* Gold, for Inſtance, out of Silver by *Aqua Regis*, and Silver out of Gold by *Aqua Fortis:* But the Reſidue of the corroded

Body remaining in the Mixture, commonly conſtitues $\frac{1}{150}$ or $\frac{1}{200}$ of the Reſidue.

PROCESS XXIV.

To determine the Quantity of the remaining Silver which Aqua Fortis *leaves in Gold.*

THIS Proceſs is not eſſentially different from *Proc.* XXII. and XXIII. N°. 2, except that many Cautions muſt be taken, and a perfect Knowledge of the Proportion of the Gold and Silver which conſtitute the Mixture, is required in the foregoing.

APPARATUS.

1. Take then of the pureſt Gold prepared according to the foregoing Proc. N°. 2. or to the XXIſt, and altogether void of Silver, one docimaſtical Mark divided into Carats, and divide this into two Parts perfectly equal: Add to each of theſe Portions the Triple, that is one Mark and a half of the pureſt Silver (*Proc.* XXIII. N°. 2. or XXII. XIX). However, that the Maſs may not be too great, you may take half a Mark inſtead of an whole one: Which muſt alſo be underſtood of the Parts of the Mark. Put every one ſeparately into two Coppels well heated. Make a ſtrong Fire, that they may be made red-hot: Then with a Ladle pour upon them one Centner of granulated tried Lead, not containing any ponderable Quantity of Gold in it. When the Lead has been conſumed in a bright Fire, leave it ſtill for one or two Minutes: Thus you will prevent the remaining of even the ſmalleſt Quantity of Lead (*Proc.* II. *Uſ.* N°. 3). If both *Regulus's* are equiponderous in the docimaſtical Balance, the Operation hitherto has ſucceeded right, which otherwiſe muſt be repeated.

2. According to theſe Rules, make ſmall thin Plates with an Anvil and Hammer, both perfectly

ſmooth and poliſhed; leſt any Thing ſhould be ſcraped off. Mean while, the Metal muſt be frequently made red-hot, under the Muffle, in a golden Diſh put upon a Trivet (*Part* I. *Plat.* II. *Fig.* XIV, XV); leſt any ſmall Scales ſhould go away from thence. Roll theſe Plates ſpirally, and after having made them red-hot again, put a ſmall Plate of each Portion ſeverally into two ſmall ſeparatory Cucurbites (*Part* I. *Plat.* II. *Fig.* XI, XII): Pour upon them ſome of the beſt tempered *Aqua Fortis*: Stop the Orifice of the Cucurbite with a Paper-Corner, or rather put upon it a Piece of flat ſmooth Glaſs: Becauſe it is requiſite that the elaſtick Spirits ſhould have a Vent left them. If the Solution goes on then but ſlowly, you may put a ſmall burning Coal under the Trivet. As for the reſt, perform the Diſſolution according to *Proc.* XXII.

However, take Care, mean while, leſt the ſmall Cucurbite be ſhaken, whereby the ſmall brittle Plates of the remaining Gold, which had hitherto preſerved their Figure perfect, might break aſunder, or any Thing of this Subſtance be rubbed off. Having then decanted the Diſſolution, invert the Cucurbites gently, that the ſmall Plate rolled up may fall ſoftly out of every one of them into the golden Diſh put underneath.

3. Then ſet the Diſh upon its Trivet, and put it under the docimaſtical Muffle, which muſt not be warmer yet than your Hand can bear, and out of which all the Aſhes, which may have fallen into it, muſt have been blown firſt with a Pair of Hand-Bellows: Increaſe the Fire ſlowly, that the Diſh may at laſt grow moderately red-hot within a Quarter of an Hour: This ſmall Plate thus heated being grown cold, put it in a good Balance, to weigh it.

4. Then let the ſmall Lamina of Gold, which is in the other ſmall Cucurbite, be roaſted in the ſame Manner, and put it in the other moveable Scale to compare it with the foregoing. They muſt be both perfectly equiponderous: if not, you have commit-

ted a Miſtake, and the Proceſs muſt be repeated. This done, put both Portions into one and the ſame Scale, and weigh them; you will find by the Difference of the Weight (N°. 1.) that the Mark of Gold employed has been increaſed one or to Grains, which proceeds from the Reſidue of Silver which the *Aqua Fortis* could not extract. But if both Portions are leſs than the Mark employed, it is an infallible Sign of a Defect, to be underſtood from the three foregoing Proceſſes. The Exceſs of Weight proceeding from the Reſidue of Silver, is called in German **Hinterhalt**, and muſt be noted exactly; that it may be ſubſtracted from the Gold in the ſubſequent Quartation; that you may not believe that there was more Gold in the Mixture, than there is in reality.

The Uſe and Reaſons of the Proceſs.

1. By the foregoing Proceſs (N°. 1.) you cannot exactly determine, how much Silver remains in the Gold after the Separation by *Aqua Fortis*: For while the Gold is diſſolved by *Aqua Regis*, it is a difficult Matter perfectly to collect the minute Duſt of Silver, to free it from the Acid of the *Aqua Regis*, and to weigh it, without ſome Part of it being diſſipated. But if Gold, diſſolved by *Aqua Regis*, is again ſeparated from it by Inſpiſſation, Roaſting, and Melting, it always ſuffers a Loſs ſuch as muſt be here conſidered over and above. For this Reaſon the Method already mentioned is choſen, to detect this Increaſe of Silver.

2. The melting of Gold with Silver, is made with greater Neatneſs and Perfection with a little Lead in a Coppel, than in a Crucible; nor is it then ſo eaſy to loſe any Thing of the Gold. Of this you will be ſure, if, after the Coppelling, you weigh again the *Regulus*, which muſt weigh four Marks: In this Caſe likewiſe you do not beſtow afterwards your Labour

in vain, when an Error has been committed in the Beginning. Nor do you loſe your Labour or Time, if, after having made ſmall Plates with the Mixture, you examine again the ſaid Plates rolled up in a Pair of Scales: For then you not only are certain whether you have committed any Error; but you at the ſame Time detect the Cauſe of it.

3. Take Care that your *Aqua Fortis* be not too much concentrated, and that the Diſſolution be not made more impetuous than is proper, by an exceſſive Heat, eſpecially in the Beginning: For by ſo doing it happens, that the *Aqua Fortis*, which corrodes the Silver out of the Interſtices of the ſmall Plates, diſjoins the Particles of the Gold by its elaſtick Effervеſcence, whence it is eaſy to loſe Part of it. Likewiſe every moiſt Body, reſolved into Fumes with great Hurry, may ſecretly carry away along with it Part of the inherent Body: Which is chiefly true with Regard to acid Spirits. Thence it is plain, that Silver mixt with Gold in much greater Quantity, may be corroded by *Aqua Fortis*, and at the ſame Time preſerve the Figure which the Gold had before, if you know what proper Strength *Aqua Fortis* ought to have.

PROCESS XXV.

To inveſtigate accurately the Allay of a Mixture of Gold and Silver.

APPARATUS.

1. According to the Carat-Mark in little (*Proc.* XXIV. N°. 1.) weigh of the Gold to be tried one half Mark; and after having found the Allay of it by proper Needles, put it into a Coppel with a ſufficient Quantity (*Proc.* VIII. N°. 1.) of Lead: That the Copper mixt with it may be conſumed. If you have made the Coppelling in the End, with a Fire ſtrong enough to diſſipate all the Lead;

you will be able to detect, by Needles of the white Allay, the Allay of the Reſidue of Silver and Gold, with ſtill greater Accuracy, than at firſt by the Needles of the mixt Allay. If you then weigh the remaining *Regulus*, you know how much Copper there was in the Mixture. This Trial may be made previouſly, to know how much Silver muſt be added ſtill, to prepare an Entrance for the *Aqua Fortis* into the Mixture.

2. Likewiſe, you muſt, for the Examination of your Gold, ſeparate two Specimens, ſtrictly obſerving the Cautions preſcribed (*Proc.* XII. Nº. 1, 2), if the Circumſtances require it. Let each of them weigh half a Mark: Put both ſeverally into two Coppels well heated, and perform the Coppelling with a ſufficient Quantity of Lead. When there is a Coruſcation, add one Centner more of granulated Lead, and ſuch a Quantity of the pureſt Silver, as that it may, together with the Silver already found in the Mixture (Nº. 1.) be threefold with regard to the Gold. We ſhall illuſtrate this Matter with an Example. Let us ſuppoſe, according to the Trial (Nº. 1.) that the half Mark has loſt four Carats of its Weight in the Coppelling: Subſtract them from the half Mark: There will remain eight Carats, which conſtitute the Gold and Silver alone: Let them be rubbed upon the Touch-ſtone, and agree with the Needle of the white Allay, which is marked with eighteen Carats of Gold, that is, in which one Part of Silver is mixt with three Parts of Gold: You thence know, that there are in the remaining *Regulus* of eight Carats, one quarter Part, that is, two Carats of Silver, and three Quarters, that is, ſix Carats of Gold. As then there muſt be three Times more Silver than Gold in the Mixture; add ſixteen Carats of Silver, which, together with the two Carats already in the Mixture, make eighteen Carats.

3. Moreover, melt the Mixture in a Coppel, with the ſame Cautions as in *Proc.* XXIV. then reduce it to ſmall Plates rolled up, and diſſolve it in the

ſame *Aqua Fortis* which you have uſed in the foregoing Proceſs; then waſh off the Salts with Water, roaſt, and, after having compared the two Reſidues in the Balance, weigh together the Gold remaining from the two half-Marks. Thus you will have found out with Certainty, and to the very leaſt Weight, the Quantity of the Gold, which at firſt you could but have gueſſed with Uncertainty: Subſtract from this Weight, as much as has been left of the Silver in the ſame Quantity, according to *Proc.* XXIV. Let us then ſuppoſe in the preſent Caſe, that the two ſmall Plates of Gold remaining, weigh twelve Carats and ſix Grains, and that the Reſidue of the Silver, according to the foregoing Proceſs, is two Grains in the whole Mark of Gold: Therefore, if there remains a little more than a half-Mark of Gold, you muſt ſubſtract one ſingle Grain; and there will remain twelve Carats and five Grains.

The Uſe and Reaſons of the Proceſs.

1. Obſerve beſides what has been ſaid in the foregoing Proceſs, that you are not to employ any other *Aqua Fortis*, but that wherewith you have tried the remaining Silver: For, ſuppoſing the other Operations to be the ſame, the Difference of this *Aqua Fortis* makes the Difference of the Reſidue. Therefore, you muſt repeat the foregoing Proceſs as many Times as you uſe other *Aqua Fortis*.

PROCESS XXVI.

The purifying of Gold by Cementation (Part I. § 459, 460.)

APPARATUS.

1. CHUSE ſome Tiles, or Bricks, not vitrified by an exceſſive Fire, nor too much tempered with Sand: The oldeſt are the beſt. Clean them well

from Lime and all other Filthineſs, pound them in an Iron-Mortar, and then ſift them through a coarſe Sieve. Take four Parts of this Powder, and one Part of Colcothar not waſhed, and of common Salt, mix them together, the more the better, and grind them in the ſame Manner, as if you would make Spirit of Salt. Moiſten theſe Powders with a little Water or Urine, ſo as that they may cohere when preſſed between your Hands.

2. Take a clean earthen Veſſel, quite ſound, ſufficiently thick, not glazed, and of the requiſite Size (*Part* I. § 218), ſtrew the Bottom of it with your moiſtened (Nº. 1.) Powder, or Cement, and diſtribute this every where with your Finger, preſſing it down very gently, ſo that the Thickneſs of the Cement may be half an Inch all about. Put upon it Gold extended in thin Plates, not thicker nor larger than a Golden Duckat, and rendered perfectly clean by making them a little red-hot in the Fire, ſo that the Cement may be covered all over with them. Then put a ſecond Layer of Cement after the foregoing Manner; and likewiſe the ſame Plates of Gold upon this as before, till the Pot is full to half an Inch Diſtance from the Brim of it. Let this remaining Space be filled up with Cement; then at laſt cover the Mouth of the Pot with a Tile, and ſtop the Joints cloſe with Lute, leſt the Spirits forced out by the Fire ſhould have the Liberty to get out.

3. Put this cementatory Pot, thus filled, into a Furnace in which ſuch a Fire may be kindled for ſeveral Hours, as that the Veſſels put into it may be made red-hot in an equal Manner: Such is the *Athanor* deſcribed (*Part* I. *Plat.* IV. *Fig.* I), in which the Veſſels may be placed under or without a Muffle; in the Middle of the Coals, or in the firſt Chamber. At firſt, make a gentle Fire, and increaſe it ſucceſſively, till the Pots grow middling red-hot, and not more: For if you ſhould uſe too great a Fire, your Gold would melt, and again be in Part ſpoiled by the ſame Things corroded off by the Vapours of the

Cement. When the Veſſels have been red-hot for ſixteen or twenty Hours, take away the Fire, that the whole may cool of itſelf.

4. This done, open the Pots, take out the Cement, which muſt be ſoftened by pouring Water upon it, in caſe it ſhould have hardened too much. If there has been any Silver in the Mixture, you muſt preſerve the Cement, as it contains in it the Metal which has been corroded from the Gold. After this, pour upon the Plates of Gold a little Water, to waſh them clean, then make them boil in other Water, which you are to renew ſeveral Times, till it is perfectly inſipid: For, there are ſaline Spirits, that lie hidden in the Plates of Gold, together with the Metal corroded by them. After that, try the Gold with the Touch-ſtone, or, more ſurely ſtill, by Quartation, whether it has the Degree of Purity which you deſire; unleſs you already know it, from a Series of repeated Experiments.

5. If your Gold is not yet ſufficiently pure, cement it anew once or twice more. Workmen commonly add ſome Salt-ammoniac to the foregoing Cement, that the other Metals may be the eaſier corroded: But in this Caſe, there muſt be no Colcothar among the Ingredients, for it ſometimes happens that Gold cannot be brought to a ſufficient Degree of Purity, on account chiefly of the Copper which it is commonly mixt with.

The Uſe and Reaſons of the Proceſs.

1. This Proceſs ſhews, that the Action of the Spirit of common Salt is different, according to its different Purity, and the different Degrees of the Fire. Likewiſe, if, inſtead of common Salt, you employ Nitre in the Cement, the Spirit of it being diſengaged, conſumes the Silver diſtributed in the greateſt Part of the Gold: Which Effect it could not produce, even the moiſt Way, though it conſtituted two Thirds of the Mixture of Silver and Gold. For

the reſt (See *Part* I. § 152, *&c.*) However, Fire cannot diſſipate any Thing of Silver diſſolved in this Manner; though it acquires ſuch a Degree of Volatility, eſpecially through the Spirit of Salt: This ſeems to proceed from the Action of the Air's being prevented.

2. Salt Ammoniac may alſo be employed in the ſecond Cement; though the Spirit of Salt is more eaſily expelled out of it, even without any Addition: which is ſhewed by the Liquid that precedes its Sublimation. Beſides, Salt Ammoniac itſelf has a very ſtrong Power over the other Metals. But, as it is ſo very dear, and the whole Buſineſs may be performed at laſt with common Salt, Cements for this Reaſon may be done without it. The ſame Thing muſt be obſerved of all the other Ingredients, which enter into Cementations, beſides thoſe already mentioned. Obſerve moreover, that, by a Variety of Additions, you ſometimes communicate to Cements a ſtony Conſiſtence, which cannot be conquered, and loſe pretty often Part of your Gold, or even change the acid Vapours to ſuch a Degree, that they cannot exert their Action, or at leaſt are of no Service at all; ſo that you increaſe your Charges much more than is neceſſary. Thus ſometimes they preſcribe ſeveral Proportions of Gem, Fountain, or Marine Salt, of which the different Effects are a perfect Secret to me. The ſame is true of the Bloodſtone, the *Crocus Martis*, the white Vitriol, the coſtly Verdigreaſe, the blew-Vitriol, the plumoſe Allum, and the like; of which Kinds of odd Mixtures we have a Multitude preſcribed by ſeveral Authors, who have written of metallick Matters.

3. If you have a Mind to purify brittle Gold by Cementation, it muſt be granulated, before you mix it with the Cement. But, as theſe Grains are not all made ſo fine, as that the Vapours may penetrate them thoroughly, the Granulation muſt be repeated as many Times, as they are to go through a new

Cementation *. But the Grains, after each Cementation, muſt be ſeparated from the Cement, by waſhing.

4. If a much greater Quantity of other Metals is mixt with the Gold, it is not proper to ſeparate them by a Cementation; but in this Caſe, the Coppel and Precipitation by Fuſion (*Part* I. § 466.) muſt be preferred.

5. As the Cement receives the Silver that was in the Gold, this may be reduced together with other the like Sweepings mixt with Gold and Silver. For this Purpoſe, thoſe Things are melted at leaſt with Lead Ore or Litharge, and with the other Droſſes of Lead, in the Manner deſcribed (*Part* I. § 240.) All the Silver and Gold is then received by the Lead, from which theſe precious Metals may afterwards be ſeparated by the Coppel.

6. There are other Cements beſides theſe, which are called *gradatory*; becauſe they give Gold, though already perfectly pure, a much deeper yellow Colour than it naturally has. But Copper, or at leaſt the Bodies proceeding from it, and not yet intirely deſtroyed, enter into all theſe Cements. For Inſtance, the Filings of Copper are calcined with Sulphur, and the *Crocus* proceeding therefrom, ſerves inſtead of Cement, either alone, or mixt with the common Ingredients of Cements; and the Gold cemented with it during twenty Hours is thereby rendered more yellow. The blue Vitriol has the ſame Virtue. But Verdigreaſe has it chiefly; and theſe Cements are commonly ſprinkled with the Solution of Sal Ammoniac, and with Vinegar. But the Colour they give proceeds from the Copper which joins with the Gold; wherefore it is again diſſipated by Lead, Antimony, and the ordinary Cements. Therefore, theſe Kinds of Cements, it ſeems, ought to be called *degradatory*, rather than *gradatory*, becauſe they in Reality render Gold impure.

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* Unleſs flatting them with an Hammer upon an Anvil may anſwer the ſame Purpoſe.

PROCESS XXVII.

The Precipitation and Purifying of Gold, by crude Antimony.

APPARATUS.

1. BEFORE you come to the Proceſs itſelf, you muſt previouſly know the Allay of your Gold: which you may try either with the Touchſtone, or with *Aqua Fortis* (Proc. XXII): For it is not neceſſary to try it by an exact Quartation. But the Diverſity of the Allay of Gold demands a certain Variety in the Way of proceeding. If then the Quantity of the Gold in the Mixture is not leſs than three Quarters, that is, eighteen Carats, the Maſs muſt be melted in a wind Furnace, and in the mean Time the Crucible be covered, to prevent Coals falling into it. This done, put into it at ſeveral Times the double Quantity of crude Antimony pulverized; in ſuch Manner that ſo ſoon as one of the Portions put into it is melted, another be immediately ſupplied: Leave theſe Things melted in the Fire for ſome Minutes more; then pour them into the melting Cone (*Part* I. *Plat.* II. *Fig.* XIX.) which muſt be warm and rubbed with Tallow, and immediately ſtrike with a Hammer the Floor on which the Cone ſtands; that the heavier Part freed from the Sulphur may the ſooner ſink to the Bottom: Invert the Cone when grown cold, and ſtrike it. The Body that was poured into it will fall out, and have at Bottom a *Regulus* more or leſs yellow, according as there was more or leſs Gold in the Mixture. This *Regulus* may, with a gentle ſtriking, be ſeparated from the ſulphureous Cruſt which is at Top.

2. Immediately after this, melt on a leſſer Fire the ſaid *Regulus* in the ſame Crucible, if it is intire: When in Fuſion, add to it the double Quantity of crude Antimony, and pour it out a little after. Se-

parate the *Regulus* from the Antimony at Top, according to N°. 1: This you may repeat even a third Time.

3. Next, put this *Regulus* into a thick Teſt well conditioned: Place it before the Bellows, according to Proceſs X, put Coals round it, and one or two Pieces of Wood upon them, and make a middling Fire, that is, ſuch as is ſufficient to melt the *Regulus*. The reguline Part of the Antimony will vaniſh in a thick Smoak: Towards the End increaſe the Fire more and more, and keep it ſo, till the Fumes are over, and the Surface of the Gold of a green and neat Colour. If the *Regulus* is but in ſmall Quantity, this Operation may be performed with a Pair of hand-Bellows. Melt the remaining Gold with Borax and Nitre, according to Proc. XXI. N°. 3; that, being freed of the ſmall Quantity of *Regulus* of Antimony which may happen to remain, it may be rendered pliant: Which may be done ſtill better by Cementation, when there is Occaſion.

4. But when the Gold is impure to an Allay of eight Carats; it is not proper to perform the Precipitation by Antimony alone: But you muſt add to the Antimony as many Times two Carats of common Sulphur, as the Allay of the Gold is ſo many Carats leſs than eighteen. As for the Reſt, let the Operation be made as N°. 1. Likewiſe let the *Regulus* be melted twice or thrice more, with crude Antimony, and the reguline Part of this, which was joined to the Gold, be diſſipated.

5. The ſulphureous Maſs ſwimming at Top of the *Regulus* (N°. 1, 2, 4), and broken off from it, contains all the Metal ſeparated from the Gold: Therefore it muſt be kept, that you may ſeparate from it the Silver together with the ſmall Quantity of Gold which has been carried away by it.

The Uſe and Reaſons of the Proceſs.

1. Crude Antimony, beſides its reguline Subſtance, has in it about one Part of common Sulphur, wherewith the *Regulus* is joined. But this Sulphur diſſolves with greater Efficacy the Silver and Copper wherewith the Gold is allayed; it abandons the *Regulus* (*Part* I. § 147. *Coroll.* 3) which ſinks gradually to the Bottom, on account of its being heavier than thoſe Metals which are diſſolved by the Sulphur, and were mixt with the Gold before. But though the Gold itſelf does not admit this Action of the Sulphur; yet while the Silver and Copper are corroded by it, a conſiderable Part of it divided into minute Particles, is carried away at the ſame Time, and will not go again to the Bottom, unleſs the *Regulus* itſelf, joining with it, ſhould conſtitute larger Particles, which are more quickly precipitated, becauſe the Surface of Contact is diminiſhed; and ſo melt into one *Regulus* together with the Gold remaining at the Bottom of the Veſſel: Whence proceeds the pale yellow Colour of the Gold.

2. When the *Regulus* is ſeparated, it muſt be melted again once or twice with freſh crude Antimony, that the remaining Silver and Copper may be ſeparated from the Gold in the ſame Manner. Whence it is plain, that the more Gold is allayed with Silver and Copper, the greater Quantity of the *Regulus* of Antimony is precipitated, and joined with the Gold; and on the contrary. Thence again, the Reaſon is plain, why the Separation of Gold from Silver and Copper is not performed as well as could be wiſhed with the Sulphur alone? Nor is it leſs evident thence, that the Separation of Gold from Silver and Copper muſt be attributed chiefly to the Sulphur of Antimony.

3. The *Regulus* of Antimony, which becomes volatile by a middling Fire, is eaſily diſſipated from the moſt fixt Gold, by the Blaſt of the Bellows; but you loſe ſomething of your Gold, when you increaſe the Fire too ſoon, and too much. Nor is it yet eaſy, by this Means, to bring Gold to a perfect

Ductility, unleſs it is afterwards melted with Nitre and Borax (*Proc.* XXI), or intirely corroded by the Cement which remained from the Antimony.

4. As then the Sulphur of Antimony takes away the menſtrual Force between the Gold, and Copper, and the Silver; and the reguline Part does but help the Precipitation; it is eaſy to find out, why it is not proper to precipitate Gold from the other Metals, with only Antimony, and that ſome more Sulphur muſt ſtill be added. For unleſs this be done, a greater Quantity of crude Antimony is required, for the ſupplying of a ſufficient Quantity of Sulphur: But then in this Caſe ſo much *Regulus* is precipitated out of it, and joined to the Gold, that you cannot diſſipate it without Loſs of your Time, Labour, and Gold: For this *Regulus* is very rapacious, nor does it altogether ſpare your Gold.

5. Such Gold, that is well purified by crude Antimony, is indeed ſo pure, that being compared with the pureſt Gold (*Proc.* XXI.) on the Touchſtone, its pale Colour, proceeding from the Silver, is not eaſily perceived; but if the very ſame Gold is diſſolved, according to *Proc.* XXI, by *Aqua Regis*, there appears nevertheleſs ſomething of the Silver.

6. As the Sulphur of Antimony has in it the Silver ſeparated from the Gold, this may again be precipitated out of it, according to *Proc.* XVI: But then at the ſame Time the remaining reguline Part of the Antimony ſinks to the Bottom together with the Silver. Let then a Specimen be ſeparated from this Mixture, and examined by Scorification (*Proc.* I.) and by Coppelling (*Proc.* II); this done, let the Reſidue of the Silver be put into *Aqua Fortis*, to know whether there remained any Gold joined with the Silver (*Proc.* XXII), and how much, if any: Which may afterwards be intirely precipitated, according to *Proc.* XXVIII, if it will pay the Charges. But the Antimony which is melted with the Gold already pure, as likewiſe that which is at three or four diffe-

rent Times put upon any Gold of any Allay whatever, has a very ſmall Quantity of Silver in it: Therefore, being hardly different from crude Antimony, if you mix it with freſh crude Antimony, it may again ſerve for the ſame Operations.

PROCESS XXVIII.

*Precipitation of Gold by Fuſion (*Part I. § 466.*) out of a Mixture eight Carats under Standard.*

IF the Quantity of the Gold in a Mark of the Mixture, does not exceed three or four Carats, it is not convenient to make a Cementation, nor a Separation by *Aqua Fortis*, nor a Precipitation by crude Antimony: Which is ſelf-evident, to any one who conſiders the Nature of theſe Operations, and the neceſſary Expences which attend them. Therefore, another Method muſt be uſed. Likewiſe, if you happen to have a Mixture of five, ſix, or ſeven Carats, fit to make a Separation by *Aqua Fortis*; you may perform the Separation the dry Way, when particular Circumſtances will not admit of the foregoing Method.

APPARATUS.

1. Find out by the Experiment of *Proc.* XXII, or by the Touch-ſtone, firſt, whether there is in the Mixture a Quantity of Gold ſufficient to pay the Charges of the Separation, and whether it does not exceed three or four Carats. This being found out, granulate the whole Mixture which is to go through the Operation. Weigh half a Mark of the Grains dried, and then examine again the Proportion of the Gold and Silver, by an accurate Coppelling and Separation in *Aqua Fortis* (*Proc.* XXV.) This you do in order to know, whether all the Gold has been precipitated out of the Silver in the following Operation,

The Uſe and Reaſons of the Proceſs.

1. This Method of Proceeding is uſed only in ſuch a Caſe, when you have a great Quantity of Silver mixt with a ſmall Quantity of Gold, nor can you determine the ſmalleſt Portion of Gold that will anſwer the Charges and Trouble of the Separation. Nevertheleſs, when Coals are cheap, and you have a good Quantity of Silver mixt with Gold, you may with ſome Profit ſeparate one or two Grains (*Part* I. § 285.) or even one Penny-weight of Gold from it.

2. The Diſſolution of Silver by Sulphur is performed in a cloſe Veſſel; otherwiſe, a vaſt Quantity of Sulphur would evaporate before the Diſſolution ſhould be made; unleſs you fix it by ſome other Body, for Inſtance by the reguline Subſtance of Antimony, as in *Proc.* XXVII, which Body, however, muſt not hinder the Action of the Sulphur upon the Silver.

Let the precipitating Flux be ſprinkled as equally as poſſible upon the melted Mixture: For if this be neglected, and the Flux is gathered in a Heap in any particular Place of the Surface; the granulated Lead, which enters into the Flux, creeps out of it as ſoon as it melts, and coming down into the Mixture precipitates the Silver, which brings the Gold along with it from that Column only through which the Lead deſcends; and, falling further down, leaves the reſt, which is adherent to the Sides, in the Mixture. For the ſame Reaſon, you muſt alſo ſtir up the Flux together with the Mixture, with an Iron-Hook. Likewiſe, Salts, Litharge, Iron, and Copper, perform a Precipitation, by abſorbing the Sulphur, but they do it ſlower and more equally than Lead, and the two laſt ſtill better, rendering at the ſame Time the Mixture ſpecifically lighter, and more fuſible, ſo that the Precipitation of the Particles of Gold and Silver is the better performed, and they hinder too great a Diſſipation of the Sulphur. For this Reaſon, Gold mixt with a ſmall Quantity of Silver

Ounce of Copper in the Mixture, nothing muſt be added. Shut the Crucible cloſe with a Tile, and fill the Furnace up to the very Brink of the Crucible, with pickt Coals of a middle Size, taking great Care not to leave any Vacuity: Kindle theſe Coals by throwing upon them burning Coals, that a Maſs ſufficiently fuſible may be melted by a middling Fire: Try with an Iron-Hook pretty thick, whether the Fuſion is perfect: Then ſtir the melted Maſs with the ſame Hook not keeping it too long immerſed, becauſe it would ſoon be conſumed. This done, have at Hand a precipitating Flux, compoſed of four Parts of granulated Lead, of Sandiver, of common Salt melted, and of Litharge one Part each, to which you may add one Part of Filings of Iron and of Copper. Weigh as many half-Ounces of this Flux, as there are Marks of the granulated Gold, and with an Iron-Spoon pour it thereupon at ſeveral Times, that it may be equally diſtributed all over the Surface of the melted *Granula.* After each Injection, ſtir the melted Maſs with an Iron-Hook: that all the Things may be well mixt: Cover the Crucible with a Tile, and leave it thus for a few Minutes, before you throw in another Portion. Mean while, you muſt here and there ſupply with freſh Coals the Fuel that is conſumed, taking great Care not to let it be wanting in any Place, leſt you ſhould thus render the Fire unequal; or leſt, the Fuel being too much diminiſhed, you ſhould be obliged to add too much Coals at one Time: For, by that Means, the Veſſels, eſpecially the larger Ones, eaſily contract Chinks, and ſpill the melted Matter.

4. After the Quantity mentioned of the precipitating Flux has been put in, let the Matter remain in the Fire for about half a Quarter of an Hour more: Then pour it into a melting Cone, rubbed within with Tallow, or, if the Quantity is too great, pour it into a warm Iron-Mortar, covered over with a thin Lute, and made very hot: Immediately after this, put the Crucible again into the Furnace, and ſurround

gentle Fire, which is ſufficient to melt the Sulphur, reſolve the Sulphur partly into Fumes, and finally make it burn: When the Flame is vaniſhed, increaſe the Fire, that the Veſſel may grow red hot: When you ſee no longer any Smoak ſmelling of Sulphur, add a Quantity of Borax, which muſt be previouſly melted, and of Sandiver, and melt the whole in a great Fire: You ſhall have a Regulus of Gold at the Bottom.

The Uſe and Reaſons of the Proceſs.

1. Gold, *Aqua Regis*, and alkaline fixt Salt, when expoſed to the Fire, do not fulminate; nor any two of theſe jointly; except that the fixt Alkali makes a ſmall crackling Noiſe with the Acid of Sea-Salt, and Nitre accelerates with great Violence the conſuming of inflammable Bodies in the Fire: But all the three, united together by Diſſolution and Precipitation, produce this Phenomenon beyond all Expectation. No body has been able hitherto to give any Explication of this Event: For thoſe, who attribute the Cauſe of it to the regenerated Nitre, do not conſider that Nitre produces no Fulmination, unleſs you add a Phlogiſton to it, and uſe a greater Fire than that required by fulminating Gold: Now, there is not in the pureſt alkaline fixt Salt a ſufficient Phlogiſton, nor do they detonate, when only joined to each other. But thoſe who fancy that the Nitre has this Phlogiſton from the Gold, are no leſs wrong: For in this Caſe, the Mixture of Gold would be diſſolved: Whereas it happens on the contrary, that the Gold appears again perfect in the Form of a very fine Powder, when this Fulmination is performed with very ſmall Portions, under a large Glaſs-Bell, and upon a very neat Surface. The crackling Noiſe of common Salt is no better an Explanation of the Caſe: For though it agrees in every Reſpect with the Fulmination of Gold, except the Violence; nevertheleſs, the Precipitation of fulminating Gold by a volatile Alkali,

by which common crackling Salt is not regenerated, is an Objection to this. The ammoniacal Subſtance which proceeds from the Acid of common Salt, &c. and from volatile Alkali, alſo detonates with Nitre: But if you take this for the Cauſe of the Detonation, the firſt Experiment is repugnant to it, by which fulminating Gold, having exactly the ſame Effect, has been produced by fixt Alkali: Nor does the Incluſion of decrepitating or detonating Salts, in the compact Body of the Gold, produce the Violence of the Fulmination: For if fulminating Gold is long boiled in Water, this its violent Strength periſhes, and the major Part of the Salts may be waſhed off: Which could never be done, if they were incloſed in the Particles of the Gold, as in ſo many Veſſels that ſhould retain and impriſon them. Therefore, the Explanation of this Point muſt ſtill be fetched out of *Democritus's* Well.

OF LEAD.

PROCESS XXX.

To reduce and precipitate Lead out of a fuſible Ore. (Part I. § 456, 466.)

APPARATUS.

1. BEAT your Ore into a coarſe Powder, juſt like the Grains of coarſe Sand: Weigh of this Powder two docimaſtical Centners, and put them into a Teſt. Put upon this a Tile or another Teſt: But you muſt ſpread the comminuted Ore as wide as poſſible in the Teſt: Roaſt it next, firſt in a gentle Fire, which muſt be gradually increaſed, till the Veſſel is almoſt red hot: Leave it thus for a few Minutes: then take off the Tile: and in a ſhort Time the blackiſh Colour of the Ore will become of a yellowiſh aſh-Colour: Which ſhews that the Sulphur is diſſipated at leaſt for the greateſt Part.

2. Beat the roaſted Ore into a ſubtil Powder, and add twice as much of the black Flux (*Part* I. § 162),

of Filings of Iron not ruſty, and of Sandiver (*Part* I. § 137.) each half a Centner. Beat all theſe Things in a Mortar, that they may be well mixt together, and put them immediately into the Crucible, or into the Skillet (*Part* I. *Plat.* II. *Fig.* V, VI, X.) having twice or thrice as much Capacity; then cover them over, a Quarter of an Inch thick, with common Salt, and preſs them with your Finger. Shut the Crucible cloſe with a Tile, or with ſome other ſmaller inverted Crucible, whoſe Brink may be received into the inferior one: Stop the Joint with ſuch Lute as may bear Fire: and then dry the whole at a moderate Heat. But the Salts muſt be very dry, and not ſuffered to melt by too great a Slowneſs in the Operation.

3. Put the Crucible into the wind-Furnace (*Part* I. § 240.) and heap Coals upon it, ſo as that it may be covered over with them a few Inches high; govern the Fire in ſuch Manner, that it may firſt grow ſlightly red hot. Soon after you will hear your common Salt crackle; and then there will be a gentle hiſſing Noiſe: So long as this laſts, keep the ſame Degree of Fire, till it is quite over. Then increaſe ſuddenly the Fire, till the whole Maſs is melted: Which may be done in a Quarter of an Hour, in a moderate melting Fire. Take out the Crucible, and put it upon the Hearth of the Furnace, which muſt be very dry: Strike it a few Times with a Hammer, that the Lead, that may perhaps be diſperſed in Grains at the Bottom of the Veſſel, may run into a ſolid *Regulus*. When the Crucible is grown cold of itſelf, and broken, you will find the *Regulus*, which, being weighed, will ſhew how much Lead the Smelters may fetch out of the Ore. But the Silver, if there chances to be any, is by that Means precipitated along with the Lead, and muſt be detected at laſt by coppelling.

4. You will know that the Operation is happily performed, if the *Scoriæ* ſubſide in the Veſſel, and if they do not foam over the Brink of the Veſſel, and thus part of them make their Way through the

Lute: Another Sign of Succeſs is, when no Particles of Lead appear ſeparate in the whole Veſſel, but when they all gather into a ſolid, tenacious, ductil, bluiſh, not very bright *Regulus*; and when the Scoria's are hard, black and ſolid, except when there are a few ſmall Cavities in the Middle, when they are contiguous with the common Salt: For the Salt does not mix with the Flux; but remains ſeparate, and ſwims at Top, being however of a black Die. When the Scoria is ſoft, light, pulverulent, taking not much leſs room than the other Things put into the Crucible, this ſhews that, the Fire having been defective both in Strength and Duration, the Lead has not on this Account been ſufficiently precipitated out of the Scoriæ; the ſame will be ſhewn by a rough *Regulus*, having high Protuberances, as alſo a blackiſh Brightneſs like that of the Lead-Ore, and finally by Grains of Lead inherent among the Scoria's eſpecially towards the Bottom, in which Caſe the Operation muſt be repeated. The laſt Caſe ſometimes happens, when a red hot Crucible is ſuddenly extinguiſhed in Water, or put up in a moiſt Place. You know from the outward ſilvery Colour of the *Regulus*, that the Fire is too great or has laſted too long; you know it alſo, when the Scoria's and the Bottom of the Veſſel appear covered with a Sort of white and neat Scale, while they are contiguous with the *Regulus*. The Operation has ſucceeded worſe ſtill, when the *Regulus* appears full of Cavities, when theſe Cavities ſeem to ſhine at the Inſide, with an Intermixture of the Colours of the Rainbow, and when the Litharge has penetrated the Bottom of the Veſſel.

The Uſe and Reaſons of the Proceſs.

1. To get Lead out of its Ore, you muſt firſt ſeparate the heterogeneous Bodies, which make the Lead appear in the State of Ore: Such is the mineral Sulphur, which conſtitutes no inconſiderable Part of

every common Lead-Ore. But this may be diſſipated by roaſting. (*See Part* I. § 464.) And as this Ore crackles, the Veſſel muſt be covered in the Beginning of the Roaſting. However let not the Veſſel grow quite red hot, but only of a dark red Colour: For this Ore eaſily grows clammy, and the Veſſel, by Corroſion, adheres ſo ſtrongly to it, that it cannot be taken off without Loſs. This Sulphur may alſo be ſeparated without roaſting, by Filings of Iron, when it melts on the Fire: but as ſome Lead Ores are charged with a ſemimetallick and chiefly antimonial Subſtance, which muſt likewiſe be ſeparated from the Lead with Iron, it is better to let the Roaſting precede: For Iron mixt with mineral Sulphur has no Action upon a Semimetal; but joints itſelf only to it; which we ſee from any Fuſion of Iron made of crude Antimony, in which the Iron abſorbs the Sulphur, and lets the reguline Subſtance ſink to the Bottom. The Fear of thoſe is altogether groundleſs, who imagine that Lead is ſpoiled by adding Iron to it; for, there is no Method known, whereby any Particle of Iron can be made to remain in Lead reduced into a metallick Form, as it is conſtantly and altogether rejected by it. (*See Part* I. § 42.)

Nor are you here to have any Regard to the refractory Quality of Iron; becauſe, when it melts together with the Subſtances which it ought to abſorb, it does it as ſoon as the Flux is added; and though it ſhould not melt, the Lead may nevertheleſs be precipitated; becauſe it does not in this Caſe adhere to the Interſtices of the Iron.

2. But as the Phlogiſton is diſſipated out of the Ore during the Roaſting, there remains a Matter that will turn into Glaſs with Fire alone: Therefore, ſomething muſt be added that may ſupply the Place of the Phlogiſton, ſuch as the black Flux (*Part* I. § 93. 162.) To this you muſt add moreover Sandiver, that will bring to a quicker Fuſion the black-Flux, which is refractory enough with regard to the

Lead; for Sandiver melts ſo ſoon as it begins to be ſlightly red. But the Veſſel muſt be cloſely ſhut, leſt the Phlogiſton ſhould be eaſily diſſipated; for Experience has taught, that, in a Veſſel well cloſed, a Piece of Charcoal, ſuch as is the black Flux, can hardly be deprived of its oily Part, on Account of the Action of the Air's being hindered: The common Salt, that ſwims at Top, ſerves alſo for the ſame Purpoſe, as it ſtops every Way all immediate Communication with the external Air.

3. You are to obſerve as to the Regimen of the Fire, that in the Beginning it muſt be moderate for a while; becauſe the Bodies reducible out of Lead, foam very much while they are reduced into a metallick Form by the Phlogiſton, which you may perceive, if you pour a ſmall Quantity of Charcoal-Duſt, upon Litharge melting ſoftly in a Teſt under the docimaſtical Muffle; and this happens by mixing a very ſmall Quantity of Phlogiſton; wherefore you ſeldom melt Litharge, but it foams and boils with a hiſſing Noiſe. For this Reaſon, if the Fire is encreaſed too much, the calcined Ore, exactly mixt with a Flux of Charcoal and Salt, riſes into a Foam, makes its Way through the Lute, and the Lead is thus for the moſt Part diſperſed in Grains. This is prevented, if you make the Fire not very great, till the Reduction is performed: Of this you have a Sign, when the noiſy Ebullition, which happens during the Reduction, ceaſes; provided it is not occaſioned by the Moiſtneſs of the Flux. But as this Reduction is performed in a Fire much greater than is neceſſary to melt the Flux itſelf, the boiling Matter is, mean while, retained by the Body ſtill remaining ſolid, and hinder'd from dilating itſelf to ſuch a Degree. Therefore, when the Reduction is at laſt made in a great Fire, you no ſooner increaſe this, but the whole melts, ſo that the Lead adhering in Grains in the Flux may be precipitated. Nevertheleſs, a too violent Fire is more hurtful, than one continued a little longer than it ought to be. For

this Reaſon, a Fire that has a Draught of Air procured without Bellows, is preferable for the performing of this Proceſs, to a Fire made with Bellows, becauſe the Fire may be governed more accurately in the former than in the latter Caſe. It is better to leave the Veſſels a little too long in the Fire, than to take them out too ſoon; for when the Fire is too ſlack, there is more of the Lead detained in the Scoria's than there can be conſumed of it, by a proportionable Exceſs of the Fire; Therefore, unleſs you perceive Signs of a very great Exceſs, there is no need of repeating the Operation; whereas the repeating of it is unavoidable, if you find that the Fire has been wanting.

PROCESS XXXI.

To reduce and precipitate Lead from an Ore rendered refractory by Pyrites.

APPARATUS.

1. ROAST two Centners of the Ore, (according to *Proc.* XXX. N°. 1.) with only this Difference, that you muſt make a Fire a little ſtronger from the Beginning to the End. The Pyrites, eſpecially that which is merely of Iron, hinders an Ore eaſily growing clammy, from turning into large Lumps, or intirely from melting. Beat the Ore roaſted and grown cold to a ſubtile Powder, and repeat the Roaſting a ſecond, and even a third Time; till, growing at laſt a little red hot in the Fire, there does remain no Smell of Sulphur at all.

2. Mix the roaſted Ore with ſix Centners of black Flux, and with two of Sandiver. Do the reſt as in the foregoing Proceſs; except that the Fire muſt be a little greater and longer continued in the End than if you had a fuſible Ore to ſmelt.

The Uſe and Reaſons of the Proceſs.

1. If the Ores of Lead are charged with Pyrites, a greater Quantity of the ſaline Flux, which diſpoſes theſe Earths to a Vitrification, is required, on Account of this refractory Quality, proceeding partly from the martial, and partly from the unmetallick Earth, and for the ſame Reaſon the Fire muſt be made a little ſtronger; that a ſufficient Precipitation of the Lead out of them may be made.

As every Pyrites already contains a martial Earth in it, which is reduced to a metallick Form, when it is melted together with an oily reducing Flux, for this Reaſon, this Earth produces here the ſame Effect, that was produced by the Uſe of the Iron-filings in the foregoing Proceſs; that is, it becomes capable of purifying Lead from the heterogeneous Bodies mentioned in the ſame Place. Nor does it hinder the Degree of the Fire which is uſed for melting the Lead-Ore, from being fit to precipitate Iron out of its Ore into a *Regulus*: For it is enough, provided it returns to its metallick State; which a middling Fire with ſome Phlogiſton will effect; for then Iron is already fit for the above-mentioned Purpoſe. But you are to obſerve, that the martial Earth deſtitute of Phlogiſton, and any Product of Iron whatever, deprived of Phlogiſton, by the Violence of the Fire, is not fit to abſorb Sulphur, Arſenick, Antimony, and the like; nevertheleſs, by joining the Phlogiſton to it again, it recovers its former Virtue. You muſt likewiſe examine, whether the Pyrites is in a ſufficient Quantity in the Lead-Ore; if not, its Defect muſt be ſupplied with a little Filings of Iron.

3. It is neceſſary to let a ſufficient Roaſting precede; for Iron, already ſaturated with Sulphur in a Pyrites, has not the ſame Effect as pure (*See Proc.* XXX. *Uſe* N°. 1.) Iron. A ſtrong Roaſting is chiefly required, when the Pyrites are arſenical; for

Arſenick is much more fixt, and more ſtrongly adherent to the Ores, than Sulphur; nay, when with a black Flux, it turns into a ſemimetallick *Regulus*, which being joined with Lead, a great Part of it moſt ſuddenly turns into (*Part* I. § 73.) Glaſs. And as there is but very little Iron in ſuch a Pyrites; that Iron has not the Virtue of hindering this Effect of the Arſenick.

4. The Lead which is got out of ſuch a pyritoſe Ore, is not commonly ſo pure as that which proceeds from a purer Ore; but it is found blackiſh and leſs ductile. The Cauſe of this Difference is Copper, which lies hidden in leſſer or greater Quantity in every Pyrites, and which is reduced at the ſame Time, and melts with the Lead into one *Regulus*; wherefore it muſt be ſeparated by a particular Eliquation.

PROCESS XXXII.

The waſhing of the Lead-Ore out of Earths and Stones.

APPARATUS.

1. THE waſhing of the Lead-Ore is performed in the ſame Manner, as that of the Silver-Ore. (*Proc.* XIII.) But take Care not to be deceived by the great Weight of the Ore; for when it is incloſed in a Matrix that is a little hard, the very brittle Lead-Ore, on Account of its foliaceous Texture, is, by the frequent Beating of the Peſtle, broken into a very thin, ſcaly Powder, which ſwims in Water, in form of a blew Powder.

2. If the remaining Ore is rendered pure by the waſhing, let it be melted, as in *Proc.* XXX. If you find it pyritoſe and full of Iron, do what has been preſcribed, *Proc.* XXXI.

PROCESS XXXIII.

To precipitate Lead out of an Ore, rendered refractory by Earths and Stones, and not waſhable.

APPARATUS.

TAKE of the roaſted Ore two Centners beaten into a ſubtil Powder, mix them with an equal Quantity of Sandiver, the more exactly, the better; add alſo ſomething of Filings of Iron, unleſs the Ore be of itſelf pyrituous; then mix the Whole with eight Centners of black Flux, and melt it as in *Proc.* XXXI.

The Uſe and Reaſons of the Proceſs.

Every thing is already clear from *Proc.* XXXI. There is need here of a very exact Comminution and Mixture, that the Scorification of the Stones mix'd with the Ore, and of the unmetallick Earth, may be performed with greater Eaſe, and that there may be no Neceſſity of promoting it with ſo ſtrong and ſo long a Fire. On this Account alſo a great Addition of the Fluxes, eſpecially of Sandiver, is required, to facilitate the Precipitation of the reduced Particles of Lead through the ſufficiently attenuated Scoria.

PROCESS XXXIV.

To reduce and precipitate Lead out of any of its Ores, by Stratification with Charcoal.

APPARATUS.

1. CHUSE for a docimaſtical Centner an hundred Half-ounces, or three common Pounds and four Half-ounces, that by this Means each Half-ounce

may ſtand in Lieu of one docimaſtical Pound. Beat ſuch a Centner of any Lead-Ore to a coarſe Powder, the Particles of which muſt be about the Size of a Pea; put it into a large Earthen or Iron-Frying-pan, and heat it firſt by a gentle Fire, which muſt be increaſed gradually, that the greateſt Part of the Sulphur may be diſſipated.

2. Have at Hand a melting-Furnace, with a Bed made of Lute and Duſt of Charcoal in its bottom-Part deſcribed (*Part* I. § 239, 240.); apply to this at the Outſide, another Bed, (*ibid. Plate* III. *Fig.* 13. *lett. i.*) and join them with Lute, that the Matter running out of the inferior Hole when open, may be received into it; ſurround this outward Bed both with freſh and burning Coals, and fill the Furnace with the ſame Fewel that it may be dried; then with a Pair of Bellows excite the Fire for a Quarter of an Hour; and then put the Ore into it at ſeveral Times; nor will it be amiſs to add to it ſome Scales * of Iron. But you muſt put the Ore in ſuch a Manner, that it may be above the Coals, facing the Hole through which the blaſt of the Bellows is admitted into the Furnace: However let it not touch the Walls of the Furnace; for if it is caſt upon the Side, where the Hole has been ſaid to be, the melted Ore in its coming down is cooled by the blaſt of the Bellows, and the ſcorificated Part remains there more refractory than the Metal itſelf: it ſtops the Paſſage of the Wind, and hinders it from exciting the Fire freely and equally: If this happens to be the Caſe, you muſt remove the Scoria with a Poker, to be introduced through the oblong Aperture of the (*Plat.* III. *Fig.* 10. *lett. c.*) Bottom-part. In the mean Time, while the Ore is put into the Fire, the Furnace muſt be filled, two thirds at leaſt, with Coals of a middling Bigneſs, and after each Portion of the Ore is put in, add a Layer of Coals above it.

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* Such as flake off from Iron red hot, while under the Strokes of a Smith's Hammer.

3. When all the Ore is put into the Fire, continue to blow till the Fire is conſumed in the Furnace. Pour Water upon the foremoſt-Bed, Drop by Drop, to cool the Lead gathered in it. Look alſo into the Scoria's, to ſee whether there are any Grains of Lead diſperſed among them; if you find it to be ſo, beat the Scoria's, and waſh the ſmalleſt Particles off with Water, that you may have the Lead ſeparate. Finally, weigh this intirely: and the Weight will anſwer to that which the Smelter will at laſt have.

The Uſe and Reaſons of the Proceſs.

1. The Lead is reduced in this Proceſs by its immediate Contact with the Coals; that is, the oily Part of the latter, being agitated by a great Fire, and intirely extorted, penetrates the ſmall vitreſcent metallick Particles, which being open by the Violence of the Fire run down through the Interſtices of the burning Coals, which, in the foregoing Proceſſes, was effected by the black Flux in cloſe Veſſels.

2. But this Method is preferable to the foregoing, except that the *Apparatus* is attended with greater Trouble. For when the Reduction is finiſhed, the Lead, collected in the Bed of the bottom Part, runs thence into the outward or foremoſt Bed: there it is preſerved by a much gentler Heat, under the burning Coals that ſupply it perpetually with a Phlogiſton, and leaves its remaining Impurity. But take Care in this Operation, if you have a mind to make your Experiment with many common Pounds Weight, not to put too much at a Time to be reduced; for, if you do this, you will not make a ſufficient Reduction, and the Fire is in ſome Meaſure ſuffocated. Nor muſt you put the roaſted Ore into the Fire, before the Furnace and the Beds are well dried and made red hot on the Inſide; for in this Caſe you will find Grains of Lead diſperſed among the Scoria's. The ſame uſes to happen, if the Ore is melted crude, or at leaſt not ſufficiently roaſted: for, the Sulphur which adheres in great Quantity to the Lead-Ore, is hardly diſſipated, and not ſeparating

quickly from the Scoria's, the Metal is rendered refractory and brittle. Beſides let the Bellows not be loaded with too great a Weight; for this deſtructible Metal is partly conſumed by the too great Violence of the Fire; eſpecially when too impetuous an Action of the Air is joined to it. Let the Noſel of the Bellows not be too narrow; that a ſufficient Blaſt may be admitted: Nor is it always poſſible to compenſate this Narrowneſs by a greater Weight; for if you load the Bellows to an Exceſs, it has been found by Experience, that the Fire is thereby rendered equal, and even diminiſhed.

3. Gold and Silver may be reduced out of the Droſs, and united with Lead by this Method; if you add to them the vitreſcent Droſs of Lead, ſuch as is Litharge, and all the Calx of Lead, and the Things in which Bodies of this nature lie hid, or even the Lead-Ores themſelves. For all theſe Things, when they have recovered their Phlogiſton, are reduced into a metallick State, they abſorb the Gold and Silver out of their Droſs, and render the refractory Scoriæ fuſible and ſoft. But the Lead thus got may be again ſeparated in a large Teſt, or even be uſed to purify ſome other Gold or Silver, ſo that the Metal which is already in the Lead, may be added to them. See *Proc.* X, XI.

PROCESS XXXV.

The Separation of Lead from Copper, by Eliquation (Part I. § 468.)

WHEN Lead has ſomething of Copper in it, it is thereby rendered leſs ductile, and when broken, the Surface of it appears as it were granulated, if the Quantity of the Copper is but very little increaſed; on the other Hand, when its Toughneſs makes it cohere, if you break it, it looks like a Heap of acute priſmatical Particles. Finally, if there is a great Quantity of pure Copper in it, it looks reddiſh; but if it is mixt with Sulphur, it looks blackiſh, and is very brittle: But the ſame Effect is produced by the Semi-Metals, as by Sulphur and Arſenick. Nevertheleſs, the Separation of the two latter has already been made in the foregoing Proceſs; but the Copper muſt be ſeparated by a peculiar *Apparatus*.

APPARATUS.

1. Make with Lute and Charcoal-Duſt a Bed, the Capacity of which muſt be proportioned to the Quantity of the Mixture of Lead and Copper to be ſeparated. But let this Bed be very low, and declining forward towards the lower Part. Let there be a ſmall narrow Channel running from the Bottom of the Bed, to the other Bed which is contiguous to the fore-Part of the former, and placed a little lower. In the Place where this Channel leads out of the End of the upper Bed; put a ſmall Iron-Plate, and preſs it acroſs the Channel ſtill moiſt; in ſuch Manner, that there remains only a ſmall Paſſage at the Bottom of it, through which the melted Lead may run ſlowly. Dry the whole well, by putting red burning Coals thereon.

2. Put the Mixture of Copper and Lead into the upper-Bed: Make in both Beds, with Wood or Charcoal, a Fire gentle enough that it may only bring the Lead to a Fuſion: This being melted by Degrees and ſlowly, will run through the narrow Paſſage left between the ſmall Iron-Plate and the Bottom of the ſmall Channel, and will be collected into a *Regulus*, in the lower Part of the foremoſt Bed. If nothing more runs with this Fire, make it a little ſtronger, till the Bed grows dark red-hot: Continue the Fire thus for ſome Minutes; and then put it out.

3. You will find the Lead collected in the inferior Bed; but the Copper that was in the Mixture, will remain in the upper-Bed, with a little Lead adhering to the Outſide of it; whence it has the Colour of it,

and is full of Pores; and if the Copper is not a quarter or a fifth Part leſs than the Portion of Lead, and the Fire has been made gentle and ſlow, you will find that it has intirely preſerved the ſame Figure, which the Mixture had before the Eliquation.

4. Find the Weight of the Copper with a Balance, and put the whole, or the melted Part of it, into a Teſt, or, if you are only willing to try it, put it into a ſmall Coppel well heated, and ſufficiently hot, till the Lead is intirely conſumed, and the Copper remains motionleſs: Then take it out immediately, and extinguiſh it in Water. You will find the former Weight of the tried Specimen diminiſhed: But the Part of it which is deficient, will be the Lead deſtroyed: And as Lead, mixt in ſmall Quantity with Copper, conſumes about the fifteenth Part of the Copper, with regard to itſelf; for this Reaſon, you muſt add the fifteenth Part of the deficient Weight to the remaining Copper, that you may have the Portion of Copper, which has been left by the Lead in the upper (N°. 2.) Bed. Thence you may eaſily calculate, how much Copper may be ſeparated from Lead. If you put the melted Lead into a Coppel, you will find not only the Portion of Gold and Silver which was in the Mixture, and which the Lead has carried away with it; but you will know alſo, from the pure ſulphureous yellow Colour of the Coppel, or from its greater or leſs Blackiſhneſs, whether nothing, or a little, or a great Quantity of the Copper has vaniſhed with the Lead; though you cannot however, from this, preciſely determine the exact Quantity of it.

The Uſe and Reaſons of the Proceſs.

1. Lead, when it is not more hot than only enough to be in Fuſion, does not diſſolve Copper: Whence Lead may be melted in a Copper-Veſſel, when you do not exceed this Degree of Fire: But,

ſo ſoon as the Lead begins to grow white, to ſmoak and boil, it ſoon diſſolves Copper: Therefore, you are to take Care, that the Fire be not too violent, eſpecially in the Beginning. But the moſt ſimple Operation of the Eliquation, is that which is performed without any Addition.

2. The ſmall Iron-Plate is applied, to the End that, in caſe a few ſmall Particles of Copper ſhould go off, theſe ſwimming at Top may be ſtopt there, and the Lead run as it were through the narrow low Paſſage left, as through a Sieve, while theſe Particles of Copper remain.

PROCESS XXXVI.

To reduce and precipitate Copper out of a pure and fuſible Ore, in a cloſe Veſſel.

APPARATUS.

1. MIX one, or, if you have ſmall Weights, two docimaſtical Centners of Ore beaten extremely fine, with ſix Centners of the black Flux, and having put them into a Crucible or a Pot, cover them one half-Inch high with common Salt, and preſs them down with your Finger: But let the Capacity of the Veſſel be ſuch, that it may be only half-full; ſhut the Veſſel cloſe; put it into the Furnace, and make the Fire as in *Proc.* XXX.

2. Increaſe the Fire ſlowly, till you hear the common Salt put upon the Ore crackle: Then increaſe the Fire immediately, either, with the Funnel and Cover put upon the Furnace, or with a Pair of Bellows applied to the Hole of the bottom-Part, that the Veſſel may grow very red hot. Thus you will precipitate and reduce your Copper in about a Quarter of an Hour: Then take out the Veſſel, and ſtrike with a few Blows the Pavement upon which you put it, that all the ſmall Grains of Copper may be collected in one Maſs.

3. Break the Veſſel, when grown cold, in two, from Top to Bottom, as neatly as you can: If the whole Proceſs has been well performed, you will find a ſolid, perfectly yellow, and malleable *Regulus*, adhering to the Bottom of the Veſſel, with Scoria's, remaining at Top of a brown Colour, ſolid, hard, and ſhining, from which the *Regulus* muſt be ſeparated with ſeveral gentle Blows of a Hammer; this done, weigh it, after having wiped off all Filthineſs.

4. A ſoft, duſty, and very black Scoria, is a Sign of a Fire not ſufficiently ſtrong. Small neat Grains of Copper reduced, but not precipitated, and adhering ſtill to Scoria's, eſpecially not very far from the Bottom; and an unequal and ramificated *Regulus*, are Signs of the ſame Thing. A ſolid, hard, ſhining, red-coloured Scoria, eſpecially about the *Regulus*, or even the *Regulus* itſelf when covered with a like ſmall Cruſt, are Signs of an Exceſs in the Degree and Duration of the Fire.

The Uſe and Reaſons of the Proceſs.

1. You may conſult what has been ſaid in *Proc.* XXX. *Uſ.* N°. 1, 2. But all the Ores which are eaſily melted in the Fire, are not the Objects of this Proceſs; for they muſt alſo be very pure. Such are the vitreous Copper-Ores, but eſpecially the green and azure coloured-ones, and the *cæruleum & viride Montanum* (Part I. § 363—366.) which is not very different from them. But if there is a great Quantity of Sulphur, Arſenick, or of the Ore of another Metal or Semi-Metal joined to the Ore of Copper, then you will never obtain a malleable *Regulus* of pure Copper; though Ores are not always rendered refractory by the Preſence of theſe.

PROCESS XXXVII.

To reduce and precipitate Copper out of Ores (Proc. XXXVI.) *rendered refractory by Earth and Stones that cannot be waſhed off.*

APPARATUS.

1. BEAT your Ore into a moſt ſubtil Powder, of which weigh one or two Centners, and mix as much Sandiver to them: This done, add likewiſe four Times as much of the black Flux, with reſpect to the Ore: For, by this Means the ſteril terreſtrial Parts are better diſpoſed to a Scorification, and the reducing and precipitating Flux may act more freely upon the metallick Particles freed of all their Incumbrances.

2. As for the reſt, make the *Apparatus* according to *Proc.* XXXVI; but you muſt make the Fire a little ſtronger for about half an Hour together. When the Veſſel is grown cold, and broken, examine the Scoria's, whether they are as they ought to be: The *Regulus* will be as ductil and fine as the foregoing.

The Uſe and Reaſons of the Proceſs.

1. Every Thing has been already explained in *Proc.* XXXIII: But as ſuch Copper-Ores hardly conceal any Sulphur and Arſenick in them, the Roaſting would be of no Effect, and a great deal of Copper would be loſt: For no metallick Calx, except thoſe of Gold and Silver, improperly ſo called, can be roaſted, without you find a Part of the Metal loſt after the Reduction: But the Stones, which here are ſuppoſed not to be elutriable, cannot be ſeparated by Fire alone: See *Part* I. § 338.

PROCESS XXXVIII.

To precipitate Copper out of an Ore (Proc. XXXVII.) *that contains Iron.*

APPARATUS.

1. DO all according to *Proc.* XXXVII. But you will find, after the Veſſel is broken, a *Regulus* upon no Account ſo fine, but leſs ductile, wherein the genuine Colour of the Copper does not perfectly appear, and which muſt be further purified.

The Uſe and Reaſons of the Proceſs.

The Fire uſed in this Operation, is not quite ſo ſtrong, as that the Iron may turn to a *Regulus:* But as Copper is the *Menſtruum* of Iron, which is of itſelf very refractory in the Fire; for this Reaſon, while the Ore and the Flux are moſt intimately mixt and confounded by Trituration, the greateſt Part of the Iron, being diſſolved by the Copper, turns into a *Regulus* along with it.

PROCESS XXXIX.

The roaſting of a pyritoſe, ſulphureous, arſenical, ſemimetallick, Copper-Ore.

APPARATUS.

1. BREAK two docimaſtical Centners of the Ore to a coarſe Powder, put them into a Teſt covered with a Tile, and place them under the Muffle of the docimaſtical Furnace: But the Fire muſt be ſo gentle, as that the Muffle may be but very faintly red hot. When the Ore has decrepitated, open the Teſt, and continue the Fire for a

few Minutes; then increaſe it by Degrees, that you may ſee the Ore perpetually ſmoaking a little: In the mean Time it is alſo proper, now and then to ſtir it up with an Iron-hook: The ſhining Particles will aſſume a dark red or blackiſh Colour: This done, take out the Teſt, that it may grow cold; if the ſmall Grains are not melted, nor ſtrongly adherent to each other, hitherto all is well; but if they run into one ſingle Cake, the Proceſs muſt be made again with another Portion of the Ore, in a more gentle Fire.

2. When the Ore is grown cold, beat it to a Powder ſomewhat finer, and roaſt it by the ſame Method as before; then take it out, and if the Powder is not melted yet, beat it again to a moſt ſubtil Powder; in this, you are to take care that nothing be loſt.

3. Roaſt the Powder a ſecond Time in a Fire ſomewhat ſtronger, but for a few Minutes only: If you do not then find the Ore any Way inclined to melt, add a little Tallow, and make it burn away under the Muffle, and do the ſame another Time again, till, the Fire being very bright, you no longer perceive any ſulphureous, arſenical, unpleaſant Smell, or any Smoak; and there remains nothing but a thin, ſoft Powder, of a dark red, or blackiſh Colour.

The Uſe and Reaſons of the Proceſs.

1. Every Pyrites contains Iron, with an unmetallick Earth: To which Sulphur or Arſenick, and moſt commonly both, (*Part* I. § 316, 323, 347, 369, 371.) always join. Beſides, there is Copper in many Pyrites, but, ſometimes more, ſometimes leſs: Some of them (*ibid.*) are altogether deſtitute of Copper. Therefore, ſo much as Pyrites differ with Regard to the Proportion of their conſtituent Particles, ſo much do they differ as to their Diſpoſition in the Fire. For inſtance, the more Copper there is in a Pyrites, the more it inclines to Colliquation. The more Sulphur and Arſenick it has in it, the more quickly the melting of it is procured, and the Reverſe: The

more Iron and unmetallick Earth it contains, the more it proves refractory in the Fire. Now, if ſuch Pyrites melt in the Roaſting, as happens to ſome of them, if they grow but a little red-hot; the Sulphur and Arſenick that lyes hidden therein, are ſo ſtrictly united with the fixt Part, that you would in vain attempt to diſſipate them: Nay, in this Caſe, when it is reduced again into a Powder, it requires a much greater Time, and Accuracy in the Regimen of the Fire, to perform the Operation. For this Reaſon it is much better to repeat it with new Pyrites. But you can roaſt no more than the double Quantity at once of the Ore you have a Mind to imploy in the foregoing Experiment: to the End that the Precipitation by Fuſion not ſucceeding, there may remain ſtill another Portion intire; leſt you ſhould be obliged to repeat a tedious Roaſting: If you ſee the Signs of a ferreous refractory Pyrites, the Operation muſt be performed with a greater Fire, and much more quickly. However, take Care not to do it with too violent a Fire: For a great deal of Copper, is conſumed not only by the Arſenick, but alſo by the Sulphur, and this happens even in Veſſels ſhut very cloſe, when the Sulphur is expelled by a Fire not quite ſo ſtrong: Which a reiterated and milder Sublimation of the Sulphur, in a Veſſel both very clean and well cloſed, will clearly ſhew.

2. When the greateſt Part of the Sulphur and the Arſenick is diſſipated, by ſuch Cauſes as promote Colliquation, you may make a ſtronger Fire: But then it is proper to add a little of ſome fat Body; for this diſſolves mineral Sulphur, it changes the Mixture of it in ſome Part, which for Inſtance conſiſts in a certain Proportion of Acid and Phlogiſton, and at the ſame Time hinders the Metallick Earth from being reduced into Copper, by being burnt to an Exceſs. From theſe Effects the Reaſon is plain, why Aſſayers produce leſs Metals in the trying of Veins of Copper, Lead and Tin, than ſkilful Smelters do in large Operations. For, the former perform the

Roaſting under the Muffle, with a clear Fire, and without an oily reducing Menſtruum; whereas the latter perform it in the Middle of Charcoal or of Wood, which perpetually emit a reductive Phlogiſton.

3. The darker and blacker the Powder of the roaſted Ore appears, the more Copper you may expect from it: But the redder it looks, the leſs Copper and the more Iron it affords: for roaſted Copper diſſolved by Sulphur or the Acid of it, is very black; and Iron, on the contrary, very red.

4. If a pure Copper-Ore lyes hidden, together with Ores of other Metals or Semi-Metals, full of Sulphur and Arſenick, in one and the ſame Glebe, that cannot be ſeparated with the Hand, it muſt be roaſted: For, while the Copper is reduced and precipitated together with theſe other Metals, it participates of their Sulphur and Arſenick; wherefore, it is the ſame as if the Ore of the Copper itſelf had been defiled by them.

PROCESS XL.

The Precipitation of Copper, out of roaſted (Proc. XXXIX.) *Ore.*

APPARATUS.

Divide the roaſted Ore into two Parts: Each of them ſhall go for a Centner: add to it the ſame Weight of Sandiver, and four Times as much of the black Flux, and mix them well together: As for the reſt, do all according to *Proc.* XXXVIII: The precipitated *Regulus* will be half-malleable, ſometimes quite brittle, now and then pretty much like pure Copper in its Colour, but ſometimes whitiſh, and even blackiſh: Whence it is moſt commonly called black Copper (in German Schwartz Kupfer); though it is not always of ſo dark a Dye.

The Uſe and Reaſons of the Proceſs.

1. It is eaſy to conceive, that there is as great a Difference between the ſeveral Kinds of this Metal called black Copper, as there is between the pyritoſe and other Copper-Ores, accidentally mixt with other metallick and Semi-metallick Bodies. For, all the Metals, the Ores of which are intermixed with the Copper-Ore, being reduced are precipitated together with the Copper; which is brought about by Means of the black Flux. Wherefore, Iron, Tin, Lead, the reguline Part of Antimony, and Biſmuth, moſt commonly are mixt with black Copper, in a Multitude of different Proportions. Nay, it is ſelf-evident that Gold and Silver, which are diſſolvable by all theſe Matters, are collected in ſuch a *Regulus*, when they have been firſt hidden in the Ore. Beſides, Sulphur and Arſenick are not always altogether abſent. For they can hardly be expelled ſo perfectly by the many preceding Roaſtings, but there remain ſome Veſtiges of them, which are not diſſipated by a ſudden Melting, eſpecially in a cloſe Veſſel, wherein the Flux ſwimming at Top hinders the Action of the Air. Nay, Arſenick is rather fixt by the black Flux, and aſſumes a reguline Semi-metallick Form, while it is at the ſame Time preſerved from diſſipating, by the Copper. But, the Variety of the Colours, of the Conſiſtence, and even of the Goodneſs of black Copper depends on this.

PROCESS XLI.

The running down of Pyritoſe, crude, Copper-Ore, into a rough, brittle Regulus, *by a Stratification with Charcoal.*

APPARATUS.

1. CHUSE a Weight of as many common half-Ounces for a docimaſtical Centner, as there are Pounds in a large Centner, that each half-Ounce may repreſent a common pound Weight; weigh in a large Balance one or many Centners of crude Ore not roaſted, and broken in ſmall Pieces of about the Bigneſs of a Pea. Let the melting Furnace have a freſh Bed, and be altogether diſpoſed as in *Proc.* XXXIV. N°. 1. and *Part* I. § 239, 240. Stop with the ſame Lute which the Bed is made of, the Hole of the Bottom-part, through which the Body melted may run from the inward into the outward and foremoſt Bed. When the Furnace and both Beds are well dried and made white hot within, put the Ore into them at ſeveral Times; mean while let the Furnace be conſtantly kept full of Coals, and the Bellows blow very ſtrongly at the ſame Time; let the Noſel of theſe be directed obliquely downwards, that it may determine the Flame towards the Surface of the inward Bed, and of the Matter which is melted in it, to make it keep in a State of Fuſion: All which Particulars muſt be obſerved more exactly than in *Proc.* XXXIV. N°. 2. becauſe of the refractory Scoria. But if you know from the outward Appearance of the Ore, or from the Experiment already made before, that this Ore, or the Scoria which will be produced out of it, is of a refractory Kind; it is proper that you ſhould add a fuſible Scoria, that has already born the Fire ſeveral Times, and is well tried that nothing of any Metal can be reduced out of it, of which you cannot de-

termine the Proportion with Regard to the Ore, otherwiſe than by Trial.

2. When you have put one Centner of the Ore into the Fire, continue the Fire, till you can judge that all the Ore is collected into the Bed: Try with an Iron-poker, which you are to introduce into the Bed through the oblong Hole of the Bottom-part, whether all the Ingredients are melted; eſpecially if the Scoria's are melted thin enough, or have a pitchy Conſiſtence; for, ſuch muſt be fetched out of the ſaid Hole with the Poker, leſt the Inferior Aperture, through which the melted Matter is conveyed into the outward Bed, ſhould be obſtructed. Then, with an Iron Rod cutting at one of its Ends, open the Hole that is ſtopt with Lute; that the melted Matter may run out into the hot foremoſt Bed. Now, if you have a Mind to melt many Centners of your Ore; remove from the Hole the ſmall Coals, or the tenacious Remains of the Scoria's; and ſtop it with freſh Lute: This done, take the hardened Maſs out of the fore-moſt Bed, with a Pair of Tongs: Then you may, in the ſame Manner, put into the Fire, melt, and convey into the foremoſt Bed, another Centner of your Ore.

3. When all the Ore you intended, has paſt through the Furnace, and the Fire is conſumed, and the Furnace grown cold, break the Beds; that you may collect what has been inſinuated into the Chinks, which they poſſibly have contracted during the Operation. Likewiſe, examine cloſely the broken Scoria's, that you may ſee whether any Thing of the reguline Part has been detained therein: This muſt be ſeparated either with the Hand, or by waſhing; and examined in the Balance together with the *Regu us* collected in the outward Bed, which is purged of all Scoria's. But, the Regulus in which the Metal lyes ſtill hidden in its State of Ore, will be very brittle.

The

The Uſe and Reaſons of the Proceſs.

1. In this Fuſion, the Ore melts on Account of too ſudden an Application of the Fire; for this Reaſon it loſes its Sulphur and Arſenick only in a ſmall Quantity (*Proc.* XXXIX. *uſ.* N° 1.) the reſt joins more ſtrictly with the fixt Subſtance of the Ore. Therefore, as Iron, which abounds in every Pyrites, ſeparates the Sulphur and Arſenick from all the other Metals and Semi-Metals, and unites them to itſelf (*Part* I. § 147. *coroll.* 1.); on this Account theſe heavy Bodies ſink to the Bottom, and the Iron, freed of Sulphur and Arſenick, ſwims at Top, together with the unmetallick Earth. But this Separation does not ſucceed ſo perfectly, but there remains ſomething of the Iron and of the unmetallick Earth in the *Regulus*, and ſome Copper in the Scoria's: The Reaſon of this is, that the Iron which is in the pyritoſe Ore is not ſufficient to abſorb all the Sulphur and Arſenick, and that by Means chiefly of the Arſenick, which, together with the Metals, turns to a reguline Semi-metallick Subſtance, Part of this ſubtil Earth remains joined to the *Regulus*. This *Regulus* is called *Lapis Cupri*, in German **Rohſtein, Kupferſtein**, *&c.* becauſe it has hitherto preſerved the Nature of the crude Pyrites.

2. But every pyritoſe Copper-Ore muſt not be made to go through this rough Melting; but only that which has a great Deal of Iron and a little Copper in it. For, the Reaſon why the melting is done here without a previous Roaſting, is, (1.) that the Iron may be ſeparated from the Copper; which is performed like a Precipitation by Fuſion, through the Action of the Sulphur upon the Iron (N° 1.): Nor could the Separation of ſo much Iron from the Copper be made with any Benefit by another Method. (2.) That the melting may be performed conveniently: For if an Iron-pyrites is deprived of its Sulphur by roaſting, it is hardly tractable by Fire alone, on Account of the refractory Nature of the martial Earth: This may

ſcorifying, but alſo of a precipitating Nature, ſince it abſorbs Sulphur and Arſenick: For a Scorification may be performed by the Lead-Ore, or its Scoria, and by adding other Fluxes: But the greateſt Part of the Lead is retained in the Scoria's, together with the metallick Part inherent in the Ores, when a Pyrites containing Iron is wanting: Nay, Lead itſelf, cannot be ſufficiently, and ſometimes not at all precipitated out of its Ore, and rendered pure, without the Aſſiſtance of Iron. (3.) A too great Quantity of Arſenick is hurtful here, and for the moſt Part hardly reducible into Glaſs, on Account of its Rapacioufneſs, and of the Deſtruction of the Lead (*Part* I. § 73.) But a great Deal of the Arſenick is alſo fixt with metallick and unmetallick Earths, and is mixt with both of them: Whence very coarſe *Regulus's* are produced; the Scoria's, on the contrary, retain a great Deal of the Metal: Thence are alſo produced Semi-arſenical Subſtances, that are diſtinct from the Scoria's and the *Regulus*, containing chiefly Copper and Iron; which are called by the German Metallurgiſts **Kupferleg**, when they contain a great Quantity of Copper with Iron; but are called **Speiſe** by the ſame, when they conſiſt only of Iron and Arſenick: Theſe have much of the unmetallick Earth in them.

PROCESS XLII.

The melting of Pyritoſe crude Copper-Ore, in a cloſe Veſſel, to make a Regulus *like that of* Proc. XLI.

APPARATUS.

1. TAKE two Centners of the ſmall docimaſtical Weight of that Ore not roaſted; beat them to a fine Powder, mix them with twice or thrice as much of pulveriſed common Glaſs, which you are to have at Hand, and which muſt be very fuſible: Or, inſtead of this uſe Scoria's altogether deſtitute of a metallick reducible Earth, and eaſily melting in the

Fire. Put them into a Crucible or Pot; and cover them over with common Salt, ſhutting the Veſſel Cloſe with a Tile, and ſtopping the Joints with Lute.

2. If theſe Things melt in the Wind-furnace, by Means of a violent Fire, you will find at the Bottom of the Veſſel a *Regulus* like that of *Proc.* XLI.

The Uſe and Reaſons of the Proceſs.

1. No ſulphureous Ore that has not been roaſted, ought to be melted by adding to it an alcaline Flux: For, fixt Alcali together with mineral Sulphur, turns to a Body, called *Hepar Sulphuris*, which retains in it diſſolved metallick Bodies (*Part* I. § 149.): For this Reaſon, if you melt in the Fire an Ore containing a great Deal of Sulphur, or of the Acid of it, with a black or a white Flux of an alcaline oily Nature; you either have no *Regulus* at all, or at leaſt the greateſt Part of it is detained in the Scoria's, that is, according as there is in the Ore a greater or a leſs Quantity of the Metal to be precipitated. If the Ore is mixt with Sandiver, and expoſed to a melting Fire, the *Regulus* is eaſily precipitated out of this moſt fuſible Salt: But this *Regulus* moſt commonly retains the Colour of the Pyrites itſelf, and when expoſed to the Air in a ſhort Time turns to a brown and very ſalt Powder; which ſhews that a great Quantity of Salt has mixt with it: Nor is the Scoria that ſwims at Top deſtitute of Metal, which renders both the Weight and Quality of the *Regulus* uncertain.

2. This Mixture of Sulphur with oily alcaline Matters, moſt commonly muſt be acknowledged to be an acceſſory Reaſon, why the Ore melted in cloſe Veſſels, or the Metal itſelf, when mixt with Sulphur, afford a leſſer Quantity of pure Metal, than when the melting is performed in an open Fire; unleſs ſome precipitating Metal is added: As, for Inſtance, Iron in the melting of Lead: But this does

not ſucceed in the preſent Caſe: for Iron, that may be mixt with Copper while it precipitates it, mixes in great Part with the precipitated Copper. For, according to the moſt accurate Experience, the precipitated participates of the precipitating Body, if not in all, at leaſt in a great many Precipitations; and this happens in the moiſt as well as in the dry ones; Nevertheleſs, this happens ſometimes more, ſometimes leſs.

PROCESS XLIII.

The further Purification of the Regulus's *of Proc.* XLI. *and* XLII, *to make* Black Copper.

APPARATUS.

LET the *Regulus* be beaten to a coarſe Powder, and be roaſted and comminuted ſeveral Times over, that the Sulphur and Arſenick may be diſſipated (*Proc.* XXXIX.): Then, let it be reduced with the black Flux (*Proc.* XL.) or by Stratification with Coals. The *Regulus* thereby produced will be like that of *Proc.* XL.

The Uſe and Reaſons of the Proceſs.

1. As the *Regulus's* of the foregoing Proceſſes, are made of the Particles of the Pyrites melted together, with this only Alteration in the Proportion of the Ingredients, that there is leſs Sulphur and Arſenick, and leſs alſo of the ſubtil unmetallick Earth in the *Regulus's* than there was in the Pyrites out of which they have been produced (*Proc.* XLI. N°. 3.): It is neceſſary to make previous Roaſtings by the ſame Methods that were preſcribed *Proc.* XXXIX, to make the black Copper ſo called *Proc.* XL. Nay, one or two Fuſions muſt ſometimes precede the Roaſtings, when the *Regulus's* are very coarſe, and tainted with a great Quantity of Iron; that the Iron may, by a repeated

Precipitation, and by the Sulphur and Arſenick ſtill remaining, be ſeparated from the Copper; whereas, both Metals would otherwiſe be confounded together by a ſubſequent Fuſion, the Sulphur and Arſenick being intirely diſſipated, and could hardly be ſeparated (*Proc.* XLI. *Uſ.* N°. 2.)

PROCESS XLIV.

To find out how much pure Copper may be produced by Scorification, out of black Copper.

WHoever attempts to find this out with the Touch-ſtone, muſt be acquainted with the Uſe of the Proof-needles (*Part* I. § 289.); one of which muſt be made of the pureſt Copper, the others of black Copper more or leſs pure; the Nature and Goodneſs of which may be aſcertained by the foregoing Experiments. Then the Copper to be examined, muſt be rubbed upon the Touch-ſtone, and compared with the Needles rubbed upon it in the ſame Manner. If the black Copper is of the beſt Kind, after having compared the Colour and Ductility of it with the Needles, you may in ſome Meaſure judge of the Goodneſs of it. But, if it is leſs pure, you can conclude nothing that is certain by this Method; becauſe the Colour and Conſiſtence of Copper may be changed by many Cauſes, ſometimes by one, ſometimes by ſeveral at once, there being a Multitude of Proportions that concur to vary it a thouſand different Ways. For, Copper, for inſtance, is rendered white equally by a great Deal of Tin, by a little of Biſmuth, and by a very little Arſenick. What will then be your Uncertainty, if many other Cauſes concur with thoſe juſt mentioned, to increaſe it! You muſt then examine your Metal by another Method.

APPARATUS.

1. Separate a Specimen of your black Copper of the Weight of two ſmall docimaſtical Centners at leaſt; and do it in the ſame Manner, and with the ſame Precautions, as if you would detect a Quantity of Silver in black Copper (*Proc.* XII. N°. 1, 2.)

2. Then with Lute and Coal-duſt make a Bed in the Cavity of a Teſt moiſtened: When this Bed is dry put it under the Muffle of the docimaſtical Furnace, in the open Orifice of which there muſt be bright burning Coals, wherewith the Teſt muſt likewiſe be ſurrounded on all Parts: When the Whole is perfectly red-hot, put your Copper into the Fire, alone, if it contains Lead; but if it is altogether deſtitute of it, add a ſmall Quantity of Glaſs of Lead, and with a Pair of Hand-bellows, increaſe the Fire, that the Whole may melt with all Speed: This done, let the Fire be made a little leſs violent, and ſuch as will ſuffice to keep the metallick Maſs well melted, and not much Greater. The melted Maſs will boil, and Scoria's will be produced that will gather at the Circumference. All the heterogeneous Matters being at laſt partly diſſipated, and partly turned to Scoria's, the Surface of the pure melted Copper will appear: So ſoon as you ſee it, take the Pot out of the Fire, and extinguiſh it in Water: Then examine it in a Balance, and if Lead has been at firſt mixt with your black Copper, add to the *Regulus* remaining of the pure Copper, one fifteenth Part of its Weight, which the Copper has loſt by Means of the Lead: Then break it with a Vice, and thus you will be able to judge by its Colour and Malleability, and by the Surface of it after it is broken, whether the purifying of it has been well performed, or no. But, whatever Caution you may uſe in the performing of this Proceſs, the Product will, nevertheleſs, be always leſs in Proportion than

what you get by a greater Operation; provided the Copper be well purified in the ſmall Trial.

Another Method.

1. Take black Copper, choſen in the ſame Manner as before (No. 1.) and break into ſmall Pieces a Quantity of it a little more than two docimaſtical Centners: This may be done very well with a Hammer and a Chizzle; that the ſmall Bits may be made of the Size of large Pieces of granulated Metal: Then reduce it to the exact Weight of two Centners: Weigh alſo two Centners of pure comminuted Copper: Add to each, being granulated, an equal Weight of pure granulated Lead, not having the leaſt Appearance of a Mixture of Copper, which may be diſtinguiſhed from a dark Colour remaining in it, when you vitrify it alone in a Coppel: Wrap up both theſe granulated Metals ſeparately in ſmall Bits of Paper.

2. Put two Coppels under the Muffle, and heat them for a While with a ſtrong Fire: This done, put your granulated Metals into them; and beſtow all your Care here to hinder the Action of the Fire from being greater upon one Coppel than upon the other. However, let the Proceſs be performed with a pretty ſtrong Fire: When all the Lead is conſumed, and the Smoak ceaſed, take both Coppels out of the Fire, as nearly at the ſame Time as poſſibly you can, and extinguiſh in Water the remaining Beads of Copper: Then weigh them, and as much as there is wanting of the two Centners of pure granulated Copper, ſo much are you to add to the *Regulus* remaining of the two Centners of black Copper; becauſe a like Quantity of it has been conſumed by the Lead: But if the black Copper contained Lead of itſelf, obſerve, beſides, the Difference of the Weights of both *Regulus's*, and add furthermore the fifteenth Part of it. You will have gathered by this Means the Weight of pure Copper that may be fetched out of the black one. Let, for Inſtance, the *Regulus* remaining of the

two Centners of pure granulated Copper weigh 186 *lb.* This has loſt 14 *lb.* by the Coppelling. If the *Regulus* remaining of the black Copper weighs 154 *lb.* you muſt of Courſe add 14 *lb.* to the 154 *lb* thereby to reſtore as much Copper, as has been conſumed of your Copper by the ſame Lead, and in the ſame Degree of Fire: The Sum 168 will indicate how many Pounds Weight of pure Copper may be fetched out of the black one. But if the black Copper had already ſome Lead in it; this being conſumed, carries away with it about the fifteenth or ſixteenth Part of the pure Copper, which muſt of Courſe be added over and above. But you may take for the Quantity of the Lead, the Difference of the *Regulus's* remaining after the coppelling; Therefore in the Example juſt propoſed, the Difference between 186 and 154 will be 32: For which Reaſon you muſt add two Pounds; and the whole Weight will be 170 *lb.* This Method proves more exact than the foregoing.

The Uſe and Reaſons of the Proceſs.

1. This is the laſt purifying of Copper, whereby the Separation of the heterogeneous Bodies begun in the foregoing Proceſſes, is completed as perfectly as it poſſibly can be. For, except Gold and Silver, all the other Metals and Semi-metals are partly diſſipated and partly burnt together with the Sulphur and Arſenick: But, in the Fuſion, they either turn of themſelves to Scoria or Fumes; or this is performed by Means of Iron, which chiefly abſorbes Semi-metals, Sulphur, and Arſenick, and the Deſtruction of it is at the ſame Time accelerated by them. Thus the Copper is precipitated out of the impure: For it is ſelf-evident, that the unmetallick Earth is expelled, the Copper being reduced from a vitreſcent terreſtrial to a metallick State, and the Arſenick being diſſipated, by Means of which the ſaid Earth has been chiefly joined to the coarſer *Regulus's* of the firſt Fuſion. But there is at the ſame Time a good Quantity of the Copper that gets into

the Scoria's; however a great Part of it may be reduced out of them by repeating the Fuſion.

2. However, though Iron, when melted alone, or even with Copper, is moſt eaſily burnt, and ſcorified; nevertheleſs, when it is once melted, and confounded with Copper, it can never be entirely ſeparated by Fire alone, without the greateſt Part of the Copper be deſtroyed along with it. Therefore, according to the Diverſity of the Ores, and of the Skill they are managed with, there is a vaſt Difference in Coppers produced by divers Proceſſes, not only from many different Ores, but even from Ores of the ſame Kind: which Difference almoſt always depends upon the Iron mixt with them: But, this is eaſily ſeparated by a little Lead: For the latter that can upon no Account be mixt with Iron in a metallick State, diſſolves the Copper, and rejects the Iron; but the Lead itſelf not being able to ſuſtain ſo ſtrong a Fire, reſolves partly into Fumes, and partly into Scoria. This is alſo the Reaſon, why a better Kind of Copper is got from Copper-Ores that contain Lead, and from black Copper from which Silver has been ſeparated by an Eliquation made with Lead, than would have been got, had Lead been altogether wanting. Therefore, when black Copper containing Lead is to be purified, it is not without Reaſon, that you add to the remaining melted Copper, the fifteenth Part of the Portion, which has been loſt in the Operation, that the Quantity of pure Copper that lies hidden in the black Copper, may be more exactly determined: On the other Hand, Iron has been ſo much rejected in the foregoing Proceſſes, that it hardly deſerves any Conſideration: Which is likewiſe true of many other Bodies that are joined with Copper. However, you muſt examine whether the other Circumſtances will permit it: Becauſe black Copper is yet ſometimes full of a great Quantity of Sulphur: But if the latter abounds, it is proper to ſeparate it before the Excoction, by roaſting, and by a reducing Fuſion, with an Addition of ſomething

thing that abſorbs Sulphur; for Inſtance, of Scoria of Iron.

3. Obſerve, as to the Application of the Fire in this Proceſs, that it muſt be applied to Copper with all imaginable Speed, to make it ſoon run: For, if you neglect this, a great Deal of your Copper is burnt: Becauſe Copper that is only red hot, cleaves much ſooner and in much greater Quantity into half ſcorified Scales, than it is diminiſhed in the ſame Time, when melted. However, too impetuous a Fire, and one much greater than is neceſſary for the Fuſion of it, deſtroys a much greater Quantity of it, than a Fire ſufficient only to put it in Fuſion, would do. For this Reaſon, when the purifying is finiſhed, the Body melted muſt be extinguiſhed in Water, together with the Veſſel; leſt being already grown hard, it ſhould ſtill remain hot for a While.

4. As there is more or leſs Copper deſtroyed by the ſame Quantity of Lead, on Account of a different Regimen of the Fire, the ſureſt Way is to make two Operations at once, when Lead is ſuperadded to the black Copper, or when the Operation is made together with Lead in a Coppel. For, by this Means, you may conclude from the Portion of pure Copper deſtroyed, the Quantity of which is exactly known, how much of the pure Copper the ſame Weight of Lead has carried away with it from the black Copper; as likewiſe, how much of it was burnt by itſelf. But, though you ſhould uſe ever ſo many Cautions, you will never have in a ſmall Proceſs a Product proportionable to that of a large one: For, imperfect Metals are ſooner or later deſtroyed, according as they are expoſed to a greater or leſs Surface of Air: Now, a ſmaller Maſs, *cæteris paribus*, is reſpectively expoſed to a larger Surface of Air, than a larger Maſs: Wherefore, more is loſt of a ſmaller than of a greater Quantity. To remedy this in ſome Meaſure, ſeveral Centners are employed for the Experiment: But the Nature of the Operation is ſuch, that

you can neither intirely correct, nor altogether exclude the Action of the Air.

5. It is proper here to mention the Danger occaſioned by a fortuitous or imprudent Application of Water, or of a moiſt, nay, of a merely cold Body, to melted Copper [*]. For, of all Metals there is none that ſcatters with ſo great a Violence all the Things round it, as melted Copper, eſpecially boiling purified Copper, called in German Gahr-Kupfer; inſomuch, that the Fall of a Coal, or of a ſmall moiſt or cold Stone, has often broken aſunder whole Furnaces, and burned whole Laboratories: And this happens eſpecially, if but a ſmall Quantity of Water extended wide, touches a large Surface of Copper. Likewiſe, Copper that begins to grow ſolid, being thrown on a moiſt, cold, but eſpecially wide Surface, flies about with great Danger to thoſe that ſtand by, and of ſetting the Building on Fire. Wherefore, if you have not a Mind to be expoſed to the ſame Danger, you muſt take Care in the Granulation of Copper by Water, that it may fall from a ſloaping Surface, or through a bored Veſſel, and with a ſmall Stream, into Water that is ſtirred about with great Force.

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[*] *N. B.* There is the ſame Danger in melted Braſs or Bell-Metal, or any other Mixture, whereof Copper makes a Part; ſo that Founders of all Sorts ſhould be equally cautious in this Reſpect: A melancholy Accident of this Kind happened at the Braſs Foundery at *Windmill-hill* near *Moorfields*, *London*, about twenty Years ago, when ſeveral People of Quality were invited to ſee the Caſting of two large Braſs Cannon at a Time; the Heat of the Metal of the firſt Gun drove ſo much Damp into the Mould of the ſecond, which was near it, that as ſoon as the Metal was let into it, it blew up with the greateſt Violence, tearing up the Ground ſome Feet deep, breaking down the Furnace, untiling the Houſe, killing many of the Spectators on the Spot with the Streams of melted Metal, and ſcalding many others in a moſt miſerable Manner.

PROCESS XLV.

Examination of the Scoria's of the foregoing Proceſſes concerning Copper.

APPARATUS.

If the Scoria is much charged with Sulphur, beat two or three docimaſtical Centners of it to a ſubtile Powder, and mix it, either alone, or, if its refractory Nature requires it, with ſome very fuſible, common, pounded Glaſs, without a reducing ſaline Flux, and melt it in a cloſe Veſſel, and in a Fire having a Draught of Air, as in *Proc.* XLII: You will have a *Regulus* like that *Proc.* XLII.

But when the Scoria has little or no Sulphur at all in it, take one Centner of it, and with the black Flux manage it as you do the fuſible Copper-Ore (*Proc.* XXXVI): You will have a pure *Regulus.*

But, if you have a Mind to try a greater Quantity of Scoria, perform the Operation according to (*Proc.* XLI.)

The Uſe and Reaſons of the Proceſs.

1. While Metals are precipitated by Scorification, and with a melting Fire, out of the ſolid Bodies in which they are incloſed, the Scoria's, on account of their Clamminess, moſt commonly retain ſomething of the Metal (*Part* I. § 98. *Schol.*): Beſides, when the juſt Quantity of Phlogiſton is wanting, and the Fire is either too ſtrong or of too long Duration, a great Deal of the already precipitated *Regulus's* of the Metals of an imperfect Mixture, being half-vitrified, turns to Scoria's again: Likewiſe, the Exceſs of Sulphur and Arſenick is oftentimes an Obſtacle to a ſufficient Precipitation, eſpecially when precipitating Matters are wanting, or miſapplied: Finally, the Deſtructibility of the Metal itſelf, hinders one from

attempting a complete Precipitation at once: It is better to ſeparate only the Part which is firſt expelled out of the Scoria's; and theſe afterwards are expoſed to a reducing reiterated Fuſion: Which Method is the more beneficial, becauſe theſe Scoria's ſerve ſometimes inſtead of a *Menſtruum* to melt other Ores, and thus leave at the ſame Time the Metal remaining in them.

2. From theſe Things, might perhaps be explained the pretended Obſervations, how a new Generation of Metals has been operated, by the Influence of the Stars and of the Atmoſphere, in Scoria's rejected a great while ago.

3. The perfect Scoria coming out of pure Copper, out of Stones, and other vitrified Bodies is of a blue Colour. But, if there is in it more Copper not quite vitrified, it looks reddiſh; and the more ſtill, as it contains more Copper: Wherefore, a great Quantity of Copper may alſo be reduced out of ſuch a Scoria. But this Colour may be intirely obſcured, by the Addition of many other Bodies, eſpecially of metallick ones: Which is chiefly effected by Iron; becauſe a ſmall Quantity of it gives the Scoria's a very black Colour. For this Reaſon, you muſt never neglect a docimaſtical Examination of the Scoria's. But the metallick *Regulus's* which are precipitated out of them, are as various as thoſe produced by the Ores themſelves. For, the *Regulus's* which is precipitated out of the Scoria's of (*Proc.* XLIII.) the pyritoſe-Ore, is much coarſer than the firſt *Regulus* proceeding from it: For a precipitating Iron lies hidden in the Scoria's united with Sulphur, when the greateſt Part of the finer Metal is expelled: Therefore, the *Regulus* which is eſpecially called by the Germans **Schlack-Stein**, is more full of Iron and Sulphur. Thus, all the *Regulus's* produced from the Scoria's are commonly leſs good than thoſe obtained by the foregoing Proceſſes: Becauſe there is a greater Number of heterogeneous, and chiefly of fixt Bodies, in the Scoria's, which, on this Account,

muſt be compared with an Ore much impurer, than that from which the Scoria's are produced.

PROCESS XLVI.

The Elutriation or Waſhing of Copper-Ore.

APPARATUS.

1. HERE every Thing muſt be done as in the Waſhing of the Ores of the foregoing Metals: But you are to obſerve in a ſpecial Manner, that the green and blue Okers of Copper (*Part* I. § 366.) admit of no waſhing; although they lie hidden in a ſoft and not very ponderous Earth: For, they are very light, and are carried to very great Diſtances, by Waters not very rapidly moved.

2. The green Copper-Ores, and the blue azure ones (*Part* I. § 364, 365.) can never go through any Roaſting, without cleaving into a light blackiſh Powder: And as Copper, next to Iron, is of all other Metals the moſt eaſily burnt away, if the roaſting is continued a little longer, or even repeated, Part of the beſt Copper is loſt, that can by no Means be recovered. For this Reaſon, as the abovesaid Ores are at once light and eaſy to be reduced to a ſubtile Powder, they will not bear waſhing, unleſs they are adherent to Earths, or at leaſt intermixt between very ſoft and light Stones, very eaſy to be comminuted by a previous Roaſting: And even in this Caſe ſome Loſs or other is hardly to be avoided. However, beware not to take for ſuch Ores thoſe, to the Surface of which a ſmall inſignificant Cruſt of the blue or the green Oker has applied itſelf.

3. The other pyritoſe, ſulphureous, Copper-Ores, incloſed in hard ponderous Stones, on Account of the Sulphur they contain, ſuffer, and even require a Roaſting; not only to the End, that the Stones may be diſpoſed to a more convenient Comminution, but alſo that the Ore itſelf may be rendered more weighty

and ſolid: For theſe Kinds of Ores are very brittle and light, and are comminuted more eaſily and finely by pounding, than the crude Stone itſelf: Whence they afterwards are, for the greateſt Part, carried away by Water.

4. Therefore, when you meet with Ores that are difficult to melt, on Account of Stones intermixt with them, and either not ſeparable at all, or at leaſt ſo with great Difficulty, and never without ſome Loſs of the Ore itſelf, it is better to manage them according to *Proc.* XLI. *Uſ.* N°. 3.

PROCESS XLVII.

To find out Copper in a pyritoſe Ore, by Solution, and a liquid Precipitation.

IF there is but a few half-Ounces of Copper in a Centner of the Pyrites; they can never be found out by a Precipitation by Fuſion: For ſo ſmall a Quantity of Copper diſperſed among ſo great a Heap of heterogeneous Matter, is unavoidably burnt away by ſo many repeated Roaſtings and Fuſions. Wherefore, a Method muſt be choſen, whereby the Copper may be ſeparated from the Ore by Means of liquid *Menſtrua*, and then again eaſily precipitated. The Acid of Sulphur, which is already in great Plenty in Pyrites, is very proper for this Operation. Make a Solution of Vitriol out of ſuch an Ore, by a light Roaſting in an open Fire, and by expoſing it afterwards to an Air ſomewhat moiſt, and pouring warm Water upon it: Next, put into this Solution ſmall Iron-Plates, extremely well poliſhed, and perfectly clean of all Greaſe. If there is any ſmall Quantity of Copper in the Pyrites, it will certainly ſtick cloſe to the Iron-Plates, in Form of a very ſubtile Powder, of a deep yellow Colour, and all of it will be fetched out of the Solution, if you have but Time enough, and a moderate Warmth: Of which more hereafter, when we treat of Vitriol. By this Means, the very leaſt Quantity of Copper is detected in Iron, when you make well ſaturated Vitriol, with Spirit of Vitriol diluted and perfectly pure. The ſame may alſo be done with ſeveral metallick Mixtures, in which Copper enters: But it would be too long here to mention the ſeveral Methods to be obſerved in this Caſe; and the Perſon that makes the Operation will eaſily find them out.

PROCESS XLVIII.

The Separation of Silver and Copper by Fuſion with Lead.

LET the Copper be freed of all heterogeneous Matters, by the Methods preſcribed in the foregoing Proceſſes: But the Gold and Silver being much more conſtant than Copper itſelf, remain therein in the foregoing Operations. But, the Copper muſt be tried, before it is intirely melted, to know whether the Quantity of Gold and Silver it contains, will repay the Charges of the Separation. For, this Separation muſt be made with Copper ſtill impure, called black Copper, by way of Fuſion with Lead; Becauſe this Separation does not ſucceed as well with melted Copper: See the Reaſon of this (*Part* I. § 468, 469). Beſides, any Portion of the Lead remaining in the Copper after the Eliquation, renders the Melting of the Copper more perfect and eaſy, than if it was performed without Lead. It will not be improper, to give a ſhort Expoſition of the Reaſons of this Proceſs: But whoever is deſirous to know the ſeveral and peculiar Furnaces, Machines, and Ways of proceeding, fit for this Purpoſe, let him peruſe the Writings of *Ercker* [*], *Agricola* [†], and others, whoſe Methods have been rectified by a certain Author in a Treatiſe **Vom Seigeren und Ertz. Beitzen.** But Mr. *Swedenborge* has collected all theſe Things[‡]. This Separation is performed chiefly by two Operations; *viz.* a juſt proportioning the Mixture with Lead, and the running off the Lead, from the Gold and Silver diſſolved by it. As the Lead is not perfectly ſeparated from the Copper by Fuſion, but there remains a Quantity of it adhering to the Copper (*Proc.* XXXV), and there remains alſo ſome Gold and Silver in the Copper, according to the Quantity of the remaining Lead; for this Reaſon, the Silver and Gold ought to be diluted in ſuch a Quantity of Lead, that in that Portion of Lead, which cannot be run off, ſo ſmall a Quantity of the above-mentioned Metals may remain diſſolved, as doth not deſerve the Addition of more Lead. You are to obſerve, that, in the Computation of the Expences, you muſt have Regard to the Loſs of Lead and Copper; ſince it is ſelf-evident, that Part of theſe Metals muſt be loſt in the Courſe of this Proceſs. You are likewiſe to examine with the ſame Exactneſs as in the Copper, by coppelling, what Quantity of Silver there is in the Lead wherewith the Separation is to be made: For, it is the ſame Thing whether Silver and Gold were already in the Lead which is to be melted down, or whether they have been received by it out of the Copper, in the Fuſion of it with the Lead. Finally, a certain Proportion is required between the Lead and the Copper; for, if the Lead exceeds ever ſo little the quadruple Quantity of the Copper, you will hardly avoid the falling of the latter into ſmall Bits, and a great Deal of it is carried away by the melted Lead. For this Reaſon, likewiſe, you are to add to your Copper, which is eaſy to be melted by itſelf, as well as with

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[*] Tranſlated into *Engliſh* by Sir *John Pettus*, under the Title of *Fleta Minor*: Or the Laws of Art and Nature, in knowing, aſſaying, &c. of Metals, *Lond.* 1686. in Folio.

[†] *De re Metallica*, Libb. XII. *Baſil.* 1621. in Folio.

[‡] In his great Work called *Emanuelis Swedenborgii Principia Rerum naturalium, ſive novorum Tentaminum Phænomena mundi Elementaris Philoſophice explicandi. Dreſdæ & Leipſiæ* 1734, in 3 Tom. in Fol.

Lead, ſome crude Copper containing Iron, and which is difficult to be run down either by itſelf or with Lead, and this chiefly, when your Copper is ſo rich in Silver and Gold, that it requires a conſiderable Addition of Lead for a ſufficient Fuſion. Neither are you to add much leſs Lead to your Copper than twice and a half the Quantity of it: Becauſe, if you diminiſh the Proportion to an Exceſs, there remains behind as much Lead, as is run off. But, they moſt commonly add as many Portions of Lead, weighing 17 *lb.* each, as there are half-Ounces of Silver and Gold in the Mixture of Copper and Lead, after the melting of them together: However, you ſubſtract as much from theſe taken together, as the Copper contained Lead before: By this Means, you may ſeparate out of one Centner of Copper, one Ounce, or even one half-Ounce of Silver. Now, if there are in your Copper ſo many half-Ounces of Silver, that as many Portions of ſeventeen Pounds weight of the ſuperadded Lead, exceed the quadruple Quantity of the Copper; this Copper muſt be mixt with Copper that is poor, or made ſuch, to obtain a juſt Proportion, or it muſt go twice through this Proceſs. But, when the Copper is rich, and there are no Obſtacles in other Reſpects, they uſe Litharge in great Part inſtead of Lead, and ſubſtitute 125 *lb.* of it, for 100 *lb.* of Lead: For you will get that Quantity of Lead from it by Reduction. They even alſo take the Scoria's remaining in the Teſts, which differ from Litharge only in Purity, and which paſs through the reducing Furnace together with the Copper, while this is melted. The Cakes or Loaves which are made of this Mixture, commonly do not contain above three Quarters of a Centner of Copper, and two or three Centners of Lead.

A great Quantity of Lead is melted out of theſe Cakes, firſt by a gentle flaming Fire, and Silver is afterwards ſeparated from it in a Teſt. But the Lead remaining of theſe Cakes is ſeparated in a

Furnace, which admits a Draught of Air ſomewhat ſtronger, and a great Deal of the Copper falls from the Cakes along with it. Theſe Matters laſtly melted out, are commonly added in the Allays of other Copper. You will find ſeveral Examples, and Methods of proceeding, in the above-mentioned Authors.

OF TIN.

PROCESS XLIX.

The Roaſting of Tin-Ore

APPARATUS.

ROAST a determined Weight, for Inſtance, ſix Centners of Tin Ore pounded to a Powder not over fine, in a Teſt, under a Muffle thoroughly red-hot, ſhutting firſt the Veſſel for a few Minutes, and then opening it. For the Melting of this Ore does not require a ſtronger Degree of Fire, than the foregoing Copper and Lead-Ores. If your Fire is pretty ſtrong, you will ſee a volatile Part of it expelled in Form of a white Smoak, of the unpleaſant Smell of Garlick: When this is over, take out the Teſt, and when the Ore is grown cold, beat it anew, and roaſt it a ſecond Time in a Fire ſomewhat ſtronger; till you no longer perceive any arſenical Fumes: Which is better detected by the Smell, when you take it out, than by the Sight of it; or if you will not make this Trial, put upon the red-hot Teſt, when taken out of the Fire, a thick, cold Plate of Iron, and look at the inferior Surface of it before it is grown very hot; this will be covered with a ſmall whitiſh Cloud, if the Metal ſtill exhales any Arſenick.

the Precipitation of the metallick Particles. Likewiſe, the Calx itſelf of reduced Tin, renders all the Scoria refractory and clammy in the Fire.

PROCESS LI.

The Reduction of Tin-Ore in a cloſe Veſſel.

APPARATUS.

THIS Proceſs is done in the ſame Manner, as the like with the Lead-Ore (*Proc.* XXX); only let the Fire be carried as ſoon as poſſible to the higheſt Degree which is neceſſary here; and ſo ſoon as you judge that the Flux is melted, take out the Veſſel, let it grow cold of itſelf, break it, and examine the Scoria and the *Regulus.*

The Uſe and Reaſons of the Proceſs.

The Examination of all Metals that are deſtructible in the Fire, and above all that of Tin by Precipitation and Reduction in cloſe Veſſels, is extremely deceitful; inſomuch that the moſt experienced Aſſayer, will moſt rarely find *Regulus's* of a perfectly equal Weight, from one and the ſame Ore, though it be comminuted, and all the Particles well mixt together, if he makes this Proceſs ſeveral Times over: For, the Ore or Calx of Tin, is refractory enough, when a Reduction is to be completed; wherefore, it requires a more violent Fire: But, reduced Tin, on the contrary, is moſt quickly deſtroyed again by the ſame Fire. You may, indeed, in ſome Meaſure judge, whether an Ore is rich, poor, or middling; but you can hardly do it to a Pound: For, during the Operation, you have no certain Sign, whether the Reduction and Precipitation are perfect, or no: And have only meer Conjectures as to that. The ſaline Flux, which helps the Scorification, has nothing to convert into Scoria but the

Tin itſelf: For, the terreſtrial adherent Particles, are ſeparated with greater Care, and more perfectly from the Tin-Ore, than from the others (*Proc.* L). Nevertheleſs, you may know from the perfect or imperfect ſaline Scoria, from the ſmall metallick Grains diſperſed among the Scoria, or even from the very Scoria proceeding from the deſtroyed Metal, which may be reduced again, but chiefly from that part next the metallick *Regulus*, whether a great Fault has been committed. Therefore, the Examination of the Tin-Ore is better done by the following Method.

PROCESS LII.

The Reduction of Tin-Ore, ex tempore.

APPARATUS.

1. CHUSE a large *, thick, extinguiſhed, and well burnt Coal of ſoft Wood, not very fibrous, nor crackling in the Fire, ſuch as lime-tree or haſle-tree Wood: Make the largeſt Surface of it flat and ſmooth with a Knife. Excavate in that Plane a Channel open in the fore-Part and above, beginning at the Side and reaching to the Middle of the Plane: Make a ſmall pretty deep Pit at the hinder Extremity of this Channel: But, the Capacity of both the Channel and the Pit muſt be ſo great, as that ſome docimaſtical Centners of the Ore, may hardly fill the third Part of both.

2. Put into the above-deſcribed Channel (N°. 1.) two docimaſtical Centners of Tin-Ore, well prepared, and beaten to a moſt ſubtile Powder, with a little of common Pitch, and let them be ſpread ſo wide, that the Ore thus heaped up, may no where come up to the Height of the Channel. Put upon this Coal another, of equal Length and Breadth, and made ſmooth in ſuch Manner, that the Channel and

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* Or a large Piece of unlighted Charcoal.

ſmall Pit may be both quite covered over. Make in the Place where the Channel and ſmall Pit are contiguous to the upper-Coal, a ſmall Hole through the whole Thickneſs of it. Then join both Coals together with an Iron-Wire, or with Lute applied at the Joints.

3. Put this *Apparatus* upon Aſhes or Sand, that it may not vacillate, and in a declining Situation, that the Aperture of the Channel may be uppermoſt, and look towards the Aſſayer, and the back-Part, where the ſmall Pit is, be much lower. Then, ſurround it on all Parts with black and burning Coals; in ſuch Manner however, that the Paſſage of the Wind through the Channel before, may not be intercepted. Now, if you blow the Fire with a Pair of hand-Bellows, ſo as that the Blaſt may enter directly into the open Extremity of the Channel, and again go out through the Hole made in the upper-Coal, the Flame following the ſame Direction, ſoon melts the Ore in the Channel, and reduces it at the ſame Time: Which is alſo helped on by the Pitch. But ſo ſoon as the Ore is in Fuſion, the Metal runs into the ſame Pit, where it is free from the great Violence of the Fire. This done (which is perceived by Sight, or felt by a ſmall Iron-Wire) remove the burning Coals around, and with a ſmall Bruſh ſprinkle it ſoftly, and Drop by Drop with Water; that the *Regulus* of Tin may indeed be quickly cooled, but not diſſipated in Grains.

PROCESS LIII.

To reduce Tin-Ore, by a Stratification with Coals

APPARATUS.

YOU muſt here obſerve all that has been ſaid of a like Proceſs (XXXIV.) with Lead: Provided the Ore be well prepared, and the Bellows be not ſo much directed downwards towards the Bed, nor blowing ſo ſtrongly. Let the Coals be ſmall, and of a ſoft Wood, that a pretty ſtrong Fire may be moſt quickly kindled, and extinguiſhed ſoon. For, if ſmall Coals are agitated with Bellows, they grow red-hot, and are conſumed much ſooner than the large ones; and if you ſprinkle them here and there with Water drop by drop with a ſmall Broom, the Fire grows of the utmoſt Strength: For which Purpoſe, likewiſe, you may put moiſtened Ore into the Fire.

OF IRON.

PROCESS LIV.

To reduce and precipitate Iron out of its Ore, in a cloſe Veſſel.

WE have already mentioned, how the martial Earth and the Iron-Ore may be known by the Action of the Magnet (*Part* I. § 359, 360.) but it is plain from what follows, that this Examination is upon no Account ſufficient. For, all Metals, Semi-Metals, Sulphur, and Arſenick, except only Antimony and Lead (which laſt is not to be conſidered, becauſe it never admits of any Mixture of Iron) being united in great Quantity with Iron by Fire, hinder not the Magnet from attracting the Iron. (*Vid. Cl. Henckelii* pyritolog. pag. 413). And though the Action of the Load-ſtone is the weaker upon Iron, as there is a greater Quantity of the Minerals juſt mentioned joined with it, and *vice verſa*; nevertheleſs, we can upon no Account conclude from the ſtrong or weak Action of the Magnet, what Quantity of Iron can be reduced out of the Ore, or out of any other martial Compound: Becauſe the various Strength of Load-ſtones, and the Quality and Proportion of the ſeveral Bodies that may be combined with Iron, occaſions a very great Difference among the Effects of the Magnet: For more may be mixt of one Body with Iron, than of ano-

ther,

ther, ſo that a Maſs cannot be attracted with equal Strength by the Load-ſtone. The eaſier and more difficult melting of Iron, and its Quality, when melted, likewiſe do depend upon theſe kinds of Mixtures. Beſides, the Bodies which are contiguous to Iron only on the Outſide, are partly taken up along with it by the Load-ſtone, let the Iron or its Ore be ever ſo finely pulverized. For this Reaſon, you muſt have Recourſe to an Examination by Fire, to know with Certainty the Quantity and Quality of the Iron to be reduced out of the Ore.

APPARATUS.

1. Roaſt for a few Minutes, in a Teſt under the Muffle, and with a pretty ſtrong Fire, two Centners of the ſmall Weight of your Iron-Ore groſly pulverized: That the Volatiles may be diſſipated in Part, and the Ore itſelf be ſoftened, in caſe it ſhould be too hard. When it is grown cold, beat it extremely fine, and roaſt it a ſecond Time, as you do the Copper-Ore, but in a much ſtronger Fire; till it no longer emits any Smell: Then let it grow cold again.

2. Compoſe a Flux of three Parts of the white Flux (*Part* I. § 163), with one Part of fuſible pulverized Glaſs, or of the like ſterile unſulphureous Scoria's; and add Sandiver and coal-Duſt of each one half-Part. Add of this Flux three Times the Quantity of your roaſted Ore, and mix the whole very well together. Then chuſe a very good Crucible, well rubbed with Lute within, to ſtop the Pores which may be here and there unſeen; put into it your Ore mixt with the Flux; cover it over with common Salt, and ſhut it cloſe with a Tile, and with Lute applied to the Joints.

3. Put the wind-Furnace upon its bottom-Part, having a Bed made of coal-Duſt (*Part* I. *Plate* III. *Fig.* X): Introduce, beſides, into the Furnace a ſmall Grate ſupported on its Iron Bars, and a Stone

upon it, whereon the Crucible may ſtand as upon a Support. Surround the Whole with hard Coals not very large, and light them at Top. When the Veſſel begins to grow red, which is indicated by the common Salt's ceaſing to crackle, ſtop with groſs [*] Lute the Holes of the bottom-Part, except that in which the Nozel of the Bellows is received: Blow the Fire, and excite it with great Force, adding now and then freſh Fuel; that the Veſſel may never be naked at Top. Having thus continued your Fire in its full Strength for three Quarters of an Hour, or for a whole Hour, take next the Veſſel out of it, and ſtrike ſeveral Times the Pavement, upon which it is ſet, that the ſmall Grains of Iron which happen to be diſperſed, may be collected into a *Regulus*, which you will find after having broken the Veſſel.

4. When the *Regulus* is weighed, try its Malleability; then make it red-hot, and, when ſo, ſtrike it with a Hammer; if it bears the Strokes of the Hammer, both when cold and when red-hot, and extends a little; you may pronounce your Iron very good: But if, when either cold or hot, or in both States, it happens to prove brittle, you may judge it not to be quite pure, but ſtill in a Semi-mineral Condition. But, the worſe the Characteriſticks of your Iron are, the greater the ſmall Grains or Furrows will be found in it when broken, which is called in German [†] Grob-Koornig, Grob-Speiſſig. Whence the Workmen, at the Sight of broken Iron, uſe to judge of its Goodneſs, though not with demonſtrative Certainty.

The Uſe and Reaſons of the Proceſs.

1. Before you reduce your Iron-Ore by Fire, the Arſenick, but much more the Sulphur, muſt be diſſipated at leaſt in Part: For the former renders the

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[*] Or Windſor-Loam. [†] Coarſe grained, coarſe fibred.

Iron, that comes out of the Ore, brittle, and, the latter not only does the ſame, but being managed in a cloſe Veſſel, with a ſaline alkaline Flux, turns to Liver of Sulphur, to the Action of which Iron yielding in every Reſpect, it can upon no Account be precipitated, and, if not the whole, a great Part of it, at leaſt, is retained by the ſulphureous Scoria; ſo that in this Caſe, you will moſt commonly look in vain for a *Regulus*. See the Effect of the Ingredients, of which the Flux is compoſed (*Part* I. § 164).

2. The Iron which is obtained from this firſt Precipitation, has hardly ever the requiſite Ductility; but is rather brittle: The Reaſon of which is, that the Sulphur and Arſenick remain in it. It is true, when a Vein of Iron is roaſted, if it abounds in both theſe Matters, it loſes the greateſt Part of them, and even the more ſo, as the Ore is leſs diſpoſed to melting: But, ſome Part of them ſeems to be ſo ſtrictly inherent in the Ore, that it can never be ſeparated, but with abſorbent, terreſtrial, alkaline Ingredients, that change the Nature of the Sulphur: For this Reaſon, in a larger Operation, they add quick-Lime, or marble Stones that turn into an acrid Calx, which, while they abſorb the ſaid Minerals, are by it, and by the Help of the deſtroyed Part of the Iron, brought to a Fuſion, and turn to a vitrified Scoria; though, at other Times, they reſiſt ſo much by their own Nature a Vitrification. Another cauſe of the Brittleneſs of Iron is the unmetallick Earth, when it is not yet ſeparated from it: For the Iron-Ore contains a great Quantity of it, and in the melting remains joined with the reguline Part: Whence the Iron is rendered very coarſe and brittle. Some Iron-Ores are altogether untractable: Nevertheleſs, the *Regulus's* produced out of them, when broken, have ſometimes a neat Semi-metallick Look: Which proceeds undoubtedly from a Mixture of a ſmall Quantity of ſome other Metal or Semi-Metal. But they generally neglect a further Examination of theſe Sorts of Mixtures, and the Methods of ſepa-

rating them, which are certainly difficult; becauſe we find almoſt every where Iron-Ores, that are both richer, and of a better Kind.

3. This Fuſion and Reduction of the Iron-Ore by Stratification with Charcoal, ſucceeds with great Difficulty in a ſmall portable *Apparatus:* For, before the Iron-Ore can be put into the Fire, the Walls of the Furnace muſt be very red-hot: Which cannot be done without ſome Detriment to the *Apparatus*, unleſs the Inſide be done over with thick Lute*. Beſides, if the Lute is not of the beſt Kind, it is almoſt conſumed by ſo violent a Fire, and by the Scoria's, as are likewiſe the Walls of the Furnace. It is better, for this Experiment to make a ſmall Furnace with Stones, in the Hearth of a Smith's Forge; then the Operation is finiſhed in the ſame Manner, as a like Proceſs with Copper. Nevertheleſs, a ſtill more violent Fire is required here; and Scoria's of Iron, or ſome other very fuſible Stones, ſometimes together with Lime, muſt be put into the Furnace before and with the Ore to be tried; not only to promote the Melting, and to ſeparate the Iron from the heterogeneous Bodies, but alſo that theſe Things ſwimming upon the *Regulus*, may hinder its being conſumed by the Fire and the Blaſt. The Furnace muſt be kept very full with Coals during the Operation, and but a ſmall Quantity of the Ore be put in at a Time.

PROCESS LV.

The melting of crude brittle Iron, to make it malleable.

TO reſtore Malleability to Iron, the Bodies which render it brittle muſt be ſeparated, and the Particles of it be made to ſtick cloſer to each other, that every heterogeneous Matter, lying hidden in its Interſtices, may be expelled. This may be conveniently done on a Hearth like that of a Smith's Forge, having a Bed

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* Of Windſor-Loam.

[illegible] coal-Duſt: Put into this Bed the Coals [illegible] Iron to be melted, heaped up in good Quan[illegible], then with the Bellows blow the Fire [illegible] ſtrongly, that the Iron may be brought to a Fuſion: And if it does not melt ſoon of itſelf, and [illegible] Quantity of Scoria's, it is neceſſary to help on the Fuſion with fuſible Scoria's, or with Sand. Let the Fire be not much greater than is neceſſary to [illegible] all theſe Matters melt as equally as poſſible: Let the melted Maſs be agitated here and there, that all the Parts of it may feel the Action of the Fire and Air equally: And let the increaſing Scoria's be taken out at one or two Times. In the mean Time, a great many Sparkles, like Rain, will be thrown out from the Iron, which diminiſh the more, as the Iron comes nearer to the deſired Degree of Purity, but they never ceaſe intirely. Then let the burning Coals be removed, and the Scoria's be conveyed out of the Fire, through a Channel made for that Purpoſe; but, when the Iron grows ſolid, let it be taken red-hot out of the Fire, and tried by ſtriking it with a Hammer: If it proves crude ſtill, let the melting be repeated: And when at laſt ſufficiently purified, let it be hammered, and extended ſeveral Ways, by making it red-hot many Times over: This done it will no longer be brittle, even when cold.

The Uſe and Reaſons of the Proceſs.

The remaining volatile Materials which make Iron brittle, and keep it in a mineral State, are diſſipated in this Operation by the Fire and Air; the terreſtrial, unmetallick, vitrified Parts, are rejected under the Form of Scoria's, while the Iron is in a perfect State of Fuſion: Nor can this, however, be done with ſufficient Exactneſs by a ſingle Fuſion: Nay, Iron does not even acquire its deſired Degree of Malleability by a ſecond Fuſion alone, but when cold, and ſtrongly hammered, it flies aſunder, or at leaſt cracks; for which Reaſon it muſt be hammered ſeveral

Times, by making it very red-hot over and over again; that the remaining terreſtrial, ſcorified Parts, may be expelled out of its Interſtices, and the metallick Particles be united together. This is called in German **Durch-ſchweiſſen**: And when the Operation is well performed, it communicates to Iron, whether red-hot or cold, its due Malleability. It is obſervable here, that any Iron, though ever ſo pure, is perfectly malleable, when melted in a reducing Fire; but yields with Difficulty to the Hammer immediately after the Fuſion. It likewiſe becomes rigid, if ſuddenly cooled, eſpecially if it is immerſed in Water: However, this Rigidity happens only in cold Weather, and is not ſo great as that of melted crude Iron, and may be perfectly reduced to its firſt State, if, after having been red-hot for a few Hours in a pure gentle Fire, it cools of itſelf very ſlowly. Nay, other hard Metals, ſuch as Copper, Braſs, Silver, and Gold, harden after the Fuſion, or after having been beaten over and over with the Hammer, but never to ſuch a Degree as Iron, and their Flexibleneſs is reſtored by the ſame Artifice, that is, by being made red-hot, and cooled by very ſlow Degrees; ſo that they afterwards grow almoſt as pliant as Lead. But you muſt take Care that there is no ſmoaking Flame proceeding chiefly from the cruder Charcoals, otherwiſe the Softening does not ſucceed. This may be obſerved chiefly in Gold, which, though very pliant and tenacious, yet becomes more rigid than Copper, when an extinguiſhed Charcoal, ſtill ſmoaking, and half burnt, falls into it, while it is perfectly red-hot, or melted in a Crucible.

As for the reſt, you muſt obſerve here, that there is no Metal, that ſuffers ſo great a Diminution of its Subſtance in the Excoction, or only in a ſimple Fuſion, as Iron does: Nay, if only made very bright red-hot, it burns away moſt ſpeedily, or cleaves into ſcorified Scales. But this Combuſtion happens quicker in malleable purified Iron, than in Iron to which Sulphur has been added.

PROCESS LVI.

The Preparation of Steel out of Iron, by Cementation.

STEEL is made of Iron in two different Manners, *viz.* by Cementation (*Part* I § 459.), or by Fuſion. The Cementation is performed in the following Manner.

APPARATUS.

1. Chuſe ſome Barrs of pure Iron, not over-thick, and quite free from heterogeneous Matters, the Flexibleneſs of it, both when hot and when cold, is a very good Sign thereof. Prepare a Cement compoſed of ſuch Ingredients as emit an abundant Phlogiſton, when agitated by the Fire, provided the ſaid Phlogiſton be altogether free from the ſulphureous mineral Acid: Such as are all extinguiſhed Coals, and in ſhort all Parts of Animals and Vegetables; among which, thoſe, however, are much ſo, which contain a greater Quantity of Oil in them, and which being freed of an exceſſive Phlegm, have been burnt before into a Semi-carbonaceous Maſs. Avoid whatever abſorbs oily Vapous with great Force, or even ſpreads the Acid of Sulphur, or the mineral Sulphur itſelf. It is better to add a few Compoſitions, in Order to clear the Matter.

Take Charcoal-duſt moderately pulveriſed 1 Pt. of Wood-aſhes ½ Pt. Mix them together.

Take Charcoal-duſt 2 Pts. Bones, Horns, Leather, Hairs of Animals (it is all one if you uſe but one, or ſeveral, or even all of them mixt together; for one of them alone is as ſufficient as the Mixture of them all) burnt with a gentle Fire till they are black in a cloſe Veſſel, then pulveriſe them 1 Pt. Wood-aſhes ½ Pt. Mix them together.

As for the reſt, it has been found, that the Parts of Animals, on Account of the Abundance of Oil they contain, are of a quicker Effect than the reſt.

2. Prepare an Earthen-veſſel, the beſt Figure of which is the Cylindrical, two or three Inches higher than the Iron-bars (N°. 1.) are long: Put into the Bottom of it your Cement prepared in the aforeſaid Manner, ſo that being gently preſſed down, it may cover the Bottom of the Veſſel to the Height of one Inch and a half. Place the Iron-bars perpendicularly, in ſuch Manner, that they may be about one Inch diſtant from the Sides of the Veſſel, and from each other: Fill the empty Interſtices with the ſame Cement; and cover alſo the Bars with it, that the Veſſel may be quite full; next cover it with a Tile, and ſtop the Joints with thin Lute.

3. When thus prepared (N°. 2.) put this Veſſel in a Furnace, where you may for ſeveral Hours maintain an equal Fire, as either in the Bottom of the Tower, or in the firſt Chamber of the Athanor (*Part* I. § 243.) Make a Fire ſo ſtrong, as that the Veſſel may be moderately red-hot for ſix or ten Hours together: When this Time is over, take it out of the Fire, and dip the red Iron-bars into cold Water. They will then be brittle, and turned to Steel, there will appear no Scoria at the Out-ſide, nor will the Weight be diminiſhed, if you have but rightly made your Proceſs according to the Regimen of the Fire.

4. The Signs of the Iron's being changed into Steel are, if being red-hot, and extinguiſhed in cold Water, it becomes very hard, not yielding to the Hammer, brittle when more ſtrongly hammered, and reſiſting the hardeſt File: By which Quality it is diſtinguiſhed from Iron rendered malleable, which indeed grows rigid when extinguiſhed in Water, but yet retains a conſiderable Degree of Ductility in the Cold, and may be extended in all Dimenſions with the Hammer. However, Steel that is cooled ſoftly, and by ſlow Degrees, may be filed and extended with

of Wood-coal, unleſs you uſe a peculiar Remedy for it.

3. Therefore, the beſt Steel made red hot a long Time, or frequently, eſpecially in an open Fire, the phlogiſtick Part being diſſipated, turns to Iron again, provided the Fire is managed, ſo as that it may not quickly turn the whole Maſs into Scoria's.

PROCESS LVII.

The Production of Steel out of crude unmalleable Iron, or out of its Ore, by Fuſion.

WE ſhall here in a clear and general Manner give the Method for making Steel by Fuſion. Chuſe for Inſtance, Iron-Ore, or the Iron itſelf ſtill crude of the firſt Fuſion, which we know can be rendered tough and firm by being melted, made red hot, and hammered. For, according as Iron, or its Ore is different in its Kind, ſo you may make with it different Sorts of Steel, and with greater or leſs Eaſe, or Difficulty. Put at one or ſeveral Times into a Bed made with Charcoal Duſt in a Smith's Forge, ſuch Quantity of this Metal divided into ſmall Parcels, as that the Metal remaining after the Melting of it is compleatly performed, may not be more than two or three common Centners; not only that the Melting may be ſooner finiſhed, but alſo becauſe a ſmall Maſs may be better and more equally penetrated with the Vapours of the Phlogiſton: Nay, they alſo add, as a defenſive Menſtruum, ſome of the vitreſcent fuſible Scoria's, either of Sand, or of ſmall Stones of the ſame Nature: Then put upon them Abundance of Charcoal, light them, and admit only a gentle Blaſt of the Bellows; that the Scoria's and the Metal may both melt very well: Take out now and then Part of the Scoria's, and often ſtir the melted Maſs with a Stick; that all the Parts of it may as much as poſſible feel the ſame Degree of Fire. Having at laſt removed the Fire and the Scoria's, ria's, and the Maſs being grown ſolid, put it upon an Anvil, and with a Hammer divide it into two Parts, which muſt be extended into long Bars by being made red-hot, and hammered ſeveral Times over: Then extinguiſh them in cold Water, whereby they are rendered ſo very hard, that they will fly aſunder when ſtruck with great Force, and will not be filable; which ſhews that the Operation has been well made. But, if you have a Mind at the firſt Time to change Iron-Ore or crude Iron into Steel, nothing but a Repetition of Trials will inform you, how long and at how many Times the Matter in Hand muſt be melted, made red-hot, and hammered. For, there are Ores, which, by a firſt Fuſion, produce Maſſes which are intermediate between malleable Iron and Steel; or reſemble Steel that is but half-Worked: Whence ſuch Steel-Ores are commonly called by the Germans * Stahl-Stein. Other Ores, on the contrary, muſt often go through a Number of long-laſting Fuſions and Hammerings, and ſometimes loſe half the Weight of the crude Iron in the firſt Fuſion, and yet never yield a right Kind of Steel. But, it is eaſy to gueſs at the Reaſon, why this Proceſs is very much forwarded, when you now and then add to your burning Coals, a fat, oily, and fixt Fewel, taken out of the animal or the vegetable Kingdom: For, the Metal muſt be penetrated by the Phlogiſton, and receive it both in great Plenty and very intimately: While, at the ſame Time, the terreſtrial and ſulphureous Particles which render the Iron crude and brittle, are diſſipated: For, the above-mentioned Fewel produces Nothing of theſe Matters, but only conſtantly ſupplies a Phlogiſton deſtitute of Acid of Sulphur. Take Care, on the contrary, not to torture your Metal with too violent, too long, and too dry a Fire, nor with an exceſſive Blaſt of Wind: Otherwiſe, you would in vain expect the deſired Change.

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* Steel Stone.

By this Means, you will prepare a good Quantity of common Steel, fit for Sale: If any Reader is deſirous to have any more particular Apparatus's, ſuch as are practiſed in ſeveral Places, he will find many of them, though no Way eſſentially different among themſelves, in *Swedenborges's* Treatiſe of Iron †.

OF MERCURY.

PROCESS LVIII.

The Separation of Mercury out of an un-ſulphureous Ore, by Diſtillation.

APPARATUS.

1. TAKE a Lump of the pulverized Ore, one common Pound, which muſt ſtand for one Centner; put it into a Glaſs Retort perfectly clean, well loricated, or coated up, to half the Length of its Neck: This muſt be very long, and turned backwards with ſuch a Declivity, that a Glaſs-Recipient may be perpendicularly applied to it. But, you muſt chuſe a Retort ſmall enough, that the Belly of it may be filled hardly two Thirds by the Ore. This Retort muſt be placed ſo, as that nothing of the Fluid adherent to the Neck of it may fall into the Cavity of the Belly, but that the Whole may run forward into the Recipient: Therefore, unleſs the Pavement of the Hearth is already high, make one *ex tempore* with Bricks, or with an Iron-plate, put upon a Trevet or ſome other high Support: It is enough if the Area of it is one Foot ſquare. In the Middle of the Hearth, put a ſmall Heap of Sand, to ſet the Retort upon, leſt it ſhould vacillate. But, the Neck muſt be ſupported, at the Place where it is neareſt to the Belly, with a ſquare Stone of a proper Height, placed

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† In the Work cited, p. 329.
And in that moſt curious and elaborate Work of Mr. *Reaumer*, entitled, *L'Art de convertir le fer forgè en Acier.* 4to.

at the Extremity of the Hearth, which will at the ſame Time hinder the Heat from affecting the Glaſs-Recipient. Finally have a ſmall Recipient, full of cold Water; let it be perpendicularly ſituated, and receive the Neck of the Retort in ſuch Manner, that the Extremity of it be hardly one half-inch immerſed into the Water; as for the reſt, it is not neceſſary to ſtop the Joints.

2. Let the Retort be ſurrounded with hot burning Coals, placed at ſome Diſtance, in Form of a Circle leſt the Veſſel ſhould burſt by too ſudden a Heat. Then by Degrees bring the burning Coals nearer and nearer, and at laſt ſurround the whole Retort with them and with freſh Charcoal: that it may grow ſlightly red-hot. This Fire having been continued for an Hour, let the Retort cool of itſelf. Then ſtrike the Neck of it gently, that the large Drops which are always adherent to it, may fall into the Recipient: When the Recipient is taken away, wipe off with a Pencil the remaining ſmaller Drops, and collect them in a low open Veſſel ſet under, leaving mean-while the Retort in its firſt Situation. Add this Portion of Mercury to the other already collected in the Recipient. Let the Water be well ſhaken firſt, and decanted, and the Mercury be poured into a Filtrum, made of a two-fold filtrating Paper; that the ſuperfluous Moiſture may be abſorbed; and then weigh it in a Glaſs-Veſſel.

3. If you have at Hand a Furnace having a Sand-bath, this Proceſs will be much more eaſily performed; but the Pot which contains the Sand muſt be middling red-hot, and the Retort be able to touch the Bottom of it immediately, nor is it then neceſſary that the Retort be loricated.

Another Method, by Deſcent.

When the Apparatus for the lateral Diſtillation (N°. 2.) is wanting, you may eaſily procure an Apparatus by Deſcent. *Viz.* Chuſe two Earthen Pots, or melting Veſſels, the Orifices of which muſt be of equal Diameter. Then adapt an Iron-plate to the Orifice of one of the two Pots in ſuch Manner, that it may indeed reſt upon the Brink of it, but not jut out too much all round: Let this Veſſel have ſeveral Holes bored here and there in it. Put it on the Pavement of the Hearth; pour into it pure Water about two Inches high; then ſhut it with the Iron-plate. Put upon this Plate a ſmall Veſſel of a leſſer Capacity, and full of a *Matrix* that contains Mercury: Next, cloſe theſe Veſſels with the ſecond Pot inverted: Stop the Joint moſt ſtrictly with Lute, which muſt be applied pretty thick all round. Bury the inferior Pot in Aſhes and Stones, placed thick and cloſe round it, and heaped up to the very Joint: Put upon theſe Things a moderate Fire, and continue it for about half an Hour, ſo that the upper Pot may grow ſlightly red-hot. The Mercury that lies hidden in the Matrix will diſſolve into Vapours, which being ſtopt above, will come down when again condenſated: They are preſerved under the Water from the too great Heat: For, this does not admit that Degree of Heat whereby the Mercury may continue in the Form of Vapours, or be reſolved into Vapours when once condenſated; unleſs there is ſome Air perfectly impriſoned in the Veſſel, and ſo incloſed as not to be able to perſpire: When the Veſſels are grown cold, open them, and ſhake well the Water contained in the inferior Pot, that all the ſmall Drops of Mercury diſperſed here and there, and adhering to the Sides of the Veſſel, may gather into one Maſs.

The Uſe and Reaſons of the Proceſs.

1. Mercury intirely volatiliſed is obtained pure by Diſtillation in a moderate Fire, without any Deſtruction, and even without any Change, unleſs the digeſting Fire is continued too long; provided the Diſtillation is performed with Diſcretion, and no

other Mineral, eſpecially Sulphur, be in the Caſe: For the latter may be mixt with Mercury by a bare Trituration, or even by Heat, and with it makes a black Powder called *The Æthiops Mineral*, which being agitated by a ſtrong Fire in a high, narrow, cloſe, glaſs or earthen Veſſel, is ſublimated, and produces that Kind of Cinnabar, which is called *factitious Cinnabar*; becauſe it is quite like that native Ore of Mercury which goes by this Name (*Part* I. § 402.) As for the reſt, you muſt uſe in this Diſtillation the ſame Precautions as in *Proc.* XVIII, where a Proceſs almoſt like this is deſcribed: Nay, this may even be performed with the ſame Apparatus, if you have it at Hand.

2. We reject here the Diſtillation by Aſcent; becauſe Mercury can hardly be forced up ſo high, without ſome Danger of the Veſſel's being cracked: Beſides, it is in this Caſe difficultly collected, and Part of it eaſily ſteals away, on Account of the too great Joints. It ſucceeds indeed better by Deſcent: Nevertheleſs, even then ſome Part of the Mercury either hides itſelf in the rough Surface of theſe Veſſels, or penetrates through the Veſſel itſelf: becauſe the latter contracts Chinks pretty often, on Account of the moiſt aqueous Vapours that make damp the upper Veſſel. Therefore, an Iron-Veſſel, if you have any, is preferable: For then, when the Joints are well ſtopt, you obtain the ſame Quantity of Mercury, as if it was expelled laterally.

3. In every Proceſs to be made by Fire with Mercury, the mercurial Vapour is to be avoided by all Means: For breathing too much of it cauſes a Salivation; and breathing little and frequently of it cauſes Tremblings, Aſthma's, Palſies, and finally Conſumptions: Nay, it is alſo hurtful to ſome, if but managed with naked and chiefly ſweating Hands.

PROCESS LIX.

The reviving of Mercury out of the ſulphureous Cinnabar-Ore (Part I. § 402.)

APPARATUS.

BEAT your Ore extremely fine, and mix it exactly with an equal Portion of Iron Filings, not ruſty: And uſe the ſame *Apparatus* as in the foregoing Proceſs, or in *Proc.* XVIII, but urge it with the ſtrongeſt Fire that can poſſibly be made; the Mercury will thus be revived.

The Uſe and Reaſons of the Proceſs.

1. When you have a Mind to ſeparate both theſe volatile Minerals, you muſt fix one of them: Which is done by any fixt Body abſorbing Sulphur: Such as Lime, fixt Alcaline Salt of what Kind ſoever, *Regulus* of Antimony, and chiefly Iron: For, theſe muſt adhere to the Sulphur alone, and no way to the Mercury. Thus will you revive any Mercury charged with Sulphur, and even diſſolved by Acids. It is obſervable in this Reviving of ſulphurated Mercury by Iron-filings, that there does not come forth the Odour of Mineral Sulphur, but an unpleaſant, and moſt ſingular Smell, which being condenſated into an unctuous rancid Matter, darkens the Sides of the Veſſels, and makes the Water turbid, into which the revived Mercury is received. But this Reviving, when accurately performed, ſhews that in the beſt Cinnabar, Mercury is above ſeven Times the Quantity of the Sulphur.

2. Cinnabar may be ſeparated from Stones by Sublimation, thus: Beat it to a fine Powder, and put it into a ſmall, narrow, glaſs, or earthen Cucurbite, the Belly of which, it muſt not fill more than one

third Part. Stop the Orifice at Top; this muſt be very narrow, to hinder the free Action of the Air: Put this ſmall Cucurbite in an earthen-Pot above two Inches wide in Diameter, and gather Sand around this Pot, about as high as the pulverized Ore riſes in the Cucurbite: Then put upon it burning Coals in ſuch Manner that the Bottom of the Pot may be middling red-hot: Thus will your Cinnabar aſcend, and form a ſolid ponderous Ring, which muſt be got out by breaking the Veſſel. Obſerve, that if you have pure Cinnabar, whether Factitious or Native, you muſt ſeparate from it the ſuperfluous Sulphur which has not been thoroughly mixt with the Murcury: This may be done very well by putting your pulverized ſulphurated Mercury into a Cucurbite, and by expoſing it to a Fire not much greater than that which is requiſite to ſublime common Sulphur: Thus will your ſuperfluous Sulphur aſcend with a little Mercury, and form a black Cruſt all over the Cavity of the Veſſel. For Sulphur and Mercury are much more volatile when ſeparate, than the Cinnabar made of both. This Sublimation muſt alſo be performed ſuddenly with a ſtrong Fire; nor are you to fear any Danger from it, provided you take Care that the upper-Part of the Veſſel be not expoſed to an exceſſive Heat; eſpecially if you make Uſe of a ſmall Matras: For, by that Means the narrow Orifice of it may be ſtopt, and the Veſſel break aſunder with great Violence.

OF ANTIMONY.

PROCESS LX.

The running down of Antimony out of its Ore.

APPARATUS.

1. CHUSE a melting Crucible, or an Earthen-pot not glazed, that may contain ſome common Pounds of the Ore of Antimony, broken into ſmall Bits, of the Size of a Haſle-Nut: Bore at the Bottom of it a few ſmall Holes, two Lines in Diameter: This may be eaſily done with a common Wimble, or, if this cannot do on Account of the Hardneſs of the Pot, with a ſmall Wedge, which muſt be moved circularly with the left Hand, and mean While inceſſantly ſtruck with a Hammer in the right. Let the Bottom of this Veſſel be received by the Orifice of a ſmaller one, upon which it muſt be put, and when the Ore is put into it, let it be covered with a Tile; and all the Joints be ſtopt cloſe with Lute.

2. Put theſe Veſſels upon the Pavement of the Hearth, and put Stones all round them, at the Diſtance of ſix Inches: Fill this intermediate Space with Aſhes, ſo high as that the inferior Pot be covered to the upper-Brim. Then put freſh and burning Coals upon it, and with a Pair of Hand-bellows excite the Fire, till the upper-Veſſel grows red-hot: Take off the Fire a Quarter of an Hour after, and when the Veſſels are grown cold, open them. You will find that the melted Antimony has run through the Holes made at the Bottom of the upper-Veſſel, and makes in the inferior one a *Regulus*, from the proportion of the Weight whereof with that of the Ore, you will be able to know how much may be got out of one Centner.

The Uſe and Reaſons of the Proceſs.

1. The Ore of Antimony, which is always found charged with Sulphur, is extremely fuſible, and when you continue too long a Fire that is ſomewhat too ſtrong, a great Quantity of it is loſt in the Form of Fumes: Nay, it burns very bright, on Account of the Abundance of the mineral Sulphur, and it cannot bear the ſaline reducing Fluxes (*Part* I. § 159, *&c.*) Therefore, this Kind of Apparatus is required for the running of it down, that the Action of the Air may in ſome Meaſure be ſtopt, and the Antimony be in a cold Place ſo ſoon as it is melted: This is done by the Aſhes wherein the inferior Veſſel is immerſed, which grow red-hot more difficultly than other Bodies, which bear the Fire: Wherefore, dry Baths are made with them rather than with Sand or Filings of Iron, when too great a Heat may be detrimental.

PROCESS LXI.

The Roaſting of crude Antimony (Proc. LX.) *or of its Ore, with, and without Additions.*

APPARATUS.

1. CHUSE an earthen, flat, low Diſh, not glazed, and if it cannot bear being made middling red-hot, cover it over with a Coat of Lute without: Spread it thinly over with crude Antimony, or with its Ore, beaten to a pretty coarſe Powder, not exceeding a few Ounces at once. Put the Diſh upon a Fire-pan, having a few burning Coals in it; increaſe the Fire, till it begins to ſmoak a little: Mean while, you muſt inceſſantly move the Powder with a Piece of a new Tobacco-pipe: For this cauſes the Sulphur to evaporate the ſooner. If you increaſe the Fire a little too ſoon, the Powder immediately gathers into

large Clots, or even begins to melt. When this happens, take it immediately off the Fire before it melts entirely: Then pulveriſe it again, and finally make a gentle Fire under it: Your black ſhining Powder will aſſume an aſh-Colour almoſt like that of Earth, and become more refractory in the Fire; wherefore, you may then increaſe the Fire till your Powder grows middling red-hot; and let it laſt, till it ceaſes to ſmoak.

2. If you add to your crude Antimony, or to its Ore pulverized, half or an equal Quantity of Charcoal-duſt, and perform the reſt as above, the Roaſting will be done more conveniently: For it does not gather ſo eaſily into Clots, and melts with much greater Difficulty: When Part of the Sulphur is evaporated, add ſome Fat to it at ſeveral Times, as in *Proc.* XXXIX. N°. 3.

Thus, you will ſooner finiſh the Operation, and the remaining *Calx* will not be burnt to an Exceſs: However, take Care, not to expoſe it thus, to too violent and long-laſting a Fire: Otherwiſe a great Quantity of it evaporates. Nor does it ceaſe intirely to ſmoak in a great Fire: And it will be enough if growing middling red-hot, it does no longer emit the unpleaſant Smell of the Acid of Sulphur.

3. This Roaſting is moſt ſpeedily performed by another Method with Nitre; if, for Inſtance, you pound Antimony charged with Sulphur, with an equal Weight of Nitre, and throw it at ſeveral Times, and not above a few Drachms at once, into a deep earthen Veſſel not glazed, and middling red-hot: A ſtrong Detonation will be made, and the Mixture will be changed into a half-vitrified Maſs, of the Colour of Liver; Take it out, grind it, and with warm Water waſh off (*Part* I. § 473. *&c.*) the Salt that lies hidden in it. The remaining Calx is called *Crocus Metallorum*, or *Hepar Antimonii* (Liver of Antimony.)

The Uſe and Reaſons of the Proceſs.

1. No Roaſting requires ſo great a Patience as that of Antimony loaded with Sulphur. For, the reguline Part of it is, by the mineral Sulphur, rendered the moſt fuſible of all Metals and Semi-metals, Arſenick excepted: But, if it melts, then a further Exhalation of the Sulphur cannot be procured by continuing the Fire, otherwiſe than by a great Loſs of the *Regulus* itſelf; which being not of itſelf very well fixt in the Fire, is the more eaſily carried away by the Sulphur joined to it, ſo that it will be entirely diſſipated along with it, though it is at leaſt above three Times the Quantity of the Sulphur. Therefore, you muſt roaſt but a ſmall Quantity of it at once, and extend it wide, and ſtir it perpetually: Becauſe, when it is too finely pulverized, or heaped up only a few Lines thick, it will not be ſeen to exhale any Thing, unleſs you ſtir it, though it already begins to melt at Bottom. For, the Vapours of the Sulphur paſſing through the Interſtices of the leſs hot Powder which is upon them, condenſate: Whereby the Powder becomes of a yellow Colour. The Roaſting is done a little more eaſily without adding any Thing to the Ore of Antimony; eſpecially if you prevent the Melting in the Beginning. As for the reſt, this Method is hardly made uſe of, except when you have a Mind to make common Glaſs of Antimony, which is made with the already prepared *Calx* of crude Antimony. For Inſtance, you put this *Calx* in a ſtrong Compact Crucible, and make your Fire gradually, leaving the Veſſel open in the Beginning; that the Sulphur ſtill remaining, may be entirely expelled: Then increaſe the Fire, till the Ore melts, the Veſſel being covered, to keep the Charcoal from falling into it, which reduces Glaſs to a reguline Semi-metallick Subſtance. When melted, leave it ſo for a Quarter of an Hour, or longer, if the Veſſels can bear it: Then at laſt, pour it out upon a flat, dry, warm Stone: It will be a Glaſs more or leſs tranſparent, and of a deep

yellow Colour; according as the Roaſting and Melting have been performed more perfectly, and in a neater Manner.

2. *Kunkel* has made Uſe of another Method of roaſting crude Antimony, in order to prepare a greater Quantity of the ſimple *Regulus* of Antimony: For, a greater Quantity of it is obtained by that Method than by any other; for, during this Roaſting the mineral Sulphur carries off a ſmall Quantity of it. But, if you urge it with a Fire too long laſting, and ſo ſtrong as that it may come almoſt to the Degree of a reducing Fire, ſome Part of it is diſſipated. For Inſtance, the *Calx* of Antimony which is of itſelf pretty well fixt, or the Glaſs of it, is diſpoſed to a Reduction, when you urge it by a frequent Addition of a Phlogiſton; now, the *Regulus* is diſſipated by a Fire a little too ſtrong; therefore, the Glaſs or Calx of Antimony is by this Method rendered volatile.

3 Nitre ground with Antimony charged with Sulphur, detonates with the ſulphureous Part, and conſumes it as to the Phlogiſton; but the Acid of Sulphur being agitated by a ſtrong Fire, and meeting the Nitre, the latter expels the acid Spirit of the former in a gentler Manner, and unites itſelf with the fixt Baſis of the Nitre, and together with it conſtitutes a middle vitriolated Salt, perfectly like Tartar vitriolate, or like Salt Polychreſt, which being waſhed off with warm Water, there remains the pure *Calx* of Antimony half vitrified. But if you uſe more Nitre, for Inſtance, twice or thrice as much for the Detonation, the *Calx* becomes yellow or white, and is much burnt; in the firſt Caſe it is called *Emetick*, and in the ſecond *Diaphoretick* Antimony.

4. The Separation of Sulphur may likewiſe be performed by ſeveral liquid Diſſolutions, and by Precipitations: For which Reaſon it is called by ſome Calcination or Roaſting the moiſt Way. Thus, for Inſtance, *Aqua Regis*, and Spirit of Nitre, eſpecially when they are concentrated, erode the reguline

Subſtance of Antimony out of the Sulphur with a moderate Heat, and diſſolve it; while they leave the Sulphur untouched: When the Solutions decanted are precipitated by a Solution of fixt alcaline Salt, and edulcorated, they produce the *Calx* of Antimony; which is nothing elſe but the intire *Regulus* diſſolved by the Acids.

PROCESS LXII.

The Reduction of the Calx's *of Antimony* (Proc. LXI.) *into a Semi-metallick* Regulus.

APPARATUS.

MIX ſome *Calx* of this Kind with a quarter Part of the black Flux, and put it into a Crucible; cover the Veſſel with a Tile; make the Fire as quickly as the Veſſels can bear it, but not greater than is neceſſary to melt the Flux itſelf: When the whole has been well in Fuſion for half a Quarter of an Hour (which may be tried with a Tobacco-pipe taking off the Tile) pour it into the melting Cone, which muſt be warm and done over with Tallow: Then immediately ſtrike the Cone ſeveral Times: When you have inverted the Cone, and ſhaken out the Matter grown cold in it, you will find at the Point a *Regulus* like (Part I. § 77), and at the Baſis a ſaline Scoria. If you have a Mind to reduce or try a ſmall Quantity of it, you muſt do it either upon a Charcoal with the cementatory or blow-Pipe (*Part* I. § 258); or in the Manner preſcribed with regard to Tin *Proc.* LII.

The Uſe and Reaſons of the Proceſs.

1. The Reduction of the *Regulus* out of the *Calx* of Antimony is performed the moſt eaſily of all Metals. It is enough, if you add to the *Calx's* of Antimony only Charcoal-duſt, or any Kind of Phlogiſton whatever: Nor need you have Recourſe to a melting *Menſtruum*, on Account of its Fuſibility. But there

happens ſome Difference, between the *Calx's* prepared (*Proc.* LXI.) for, more or leſs *Regulus* may be reduced out of one or the other, not only with regard to the crude Antimony, but alſo with reſpect to the *Calx* you make Uſe of. For Inſtance, you will obtain, after the Reduction, above one Pound of *Regulus*, out of one Pound and an half of crude Antimony either alone, or roaſted with Charcoal-duſt; unleſs you have committed ſome Miſtake, by making too great and too long laſting a Fire, or by uſing impure Antimony: For, by the firſt Method, you will prepare pure, unmixed *Calx* of Antimony, by the Diſſipation of the mineral Sulphur and the Phlogiſton; but you cannot prepare any Calx ſtrictly ſo called by the ſecond Method, that is, with Charcoal-duſt; becauſe, a pure Phlogiſton, that is, one deſtitute of Acid of Sulphur, has been continually ſupplied, during the Diſſipation of the mineral Sulphur: Therefore, in this Caſe, the reguline Part cannot have been burnt into a true *Calx*; but, being only ſeparated, it had merely a falſe Appearance of a *Calx*: For, if you take this out of the roaſting Fire in proper Time, and expoſe it to a melting Fire in a Veſſel; it does not melt into Glaſs, but into a *Regulus*, not ſo abundant however, as if freſh reducing Powder had been added. But, it is always proper, when you are to prepare an abundant *Regulus*, or a fine Glaſs, to chuſe that Part of the crude Antimony, which in the running down (*Proc.* LX.) got into the lower Part of the Recipient; for it is purer, more reguline, and leſs ſulphureous; whereas that in the upper Part proves leſs reguline, and more ſulphureous and terreſtrial: On which Account it appears leſs compact and ſhining than the foregoing, and much lighter, becauſe full of ſmall Bubbles.

2. Before you reduce the *Calx's* made by a Detonation with Nitre, you muſt previouſly edulcorate them perfectly: Otherwiſe, you obtain a much leſſer Quantity of *Regulus*, with regard both to the crude Antimony and to the *Calx* itſelf; becauſe, when you

add a Phlogiſton, the vitriolated Salt adhering to it, turns to Liver of Sulphur, which diſſolves the *Regulus*, and in very great Part retains it joined to itſelf. Nor can you, however, thus obtain ſo much *Regulus*, as when the Calcination is made either by itſelf, or with only adding a Phlogiſton: For during ſo violent a Detonation, a great Quantity is flung out of the Veſſel, or vaniſhes away into Fumes: Beſides, ſome Part of the reguline Subſtance is alſo waſhed off along with the Salt; which is very plain, when you pour wine-Vinegar upon the the Water wherewith the Edulcoration has been made: By Means of which you precipitate a red Powder, called *Sulphur Auratum*, which is compoſed of the Sulphur of your Antimony joined to the Semi-metallick Part. For, the Phologiſton of the crude Antimony, is not totally conſumed by an equal Weight of Nitre: But, if you add twice or thrice as much Nitre; then indeed, it is totally conſumed: However, a Semi-metallick Part remains ſo ſtrictly united with the Salt, that it runs through the Filters. As this laſt part is obtained out of the warm Diſſolution, in the ſame Manner as the *Lac Sulphuris* and the *Sulphur Auratum* are got by Precipitation; it has been but improperly called fixt Sulphur of Antimony: For it is deprived of all inflammable Matter, on which Account it is of a white Colour. It is for the ſame Reaſon, that the Sulphur called fixt Sulphur of Antimony, being melted with a very ſtrong Fire, turns into Glaſs, of a much lighter Colour, and leſs violent in its Effects, than that which is made of *Crocus* of Antimony, becauſe it is almoſt the ſame as Glaſs made with *Calx* of Antimony procured without any Addition.

3. From what has been ſaid the Reaſon is plain, why ſimple *Regulus* of Antimony is prepared with ſome Loſs the ordinary Way. For a Mixture of Tartar, Nitre, and crude Antimony, detonates in a ſtrong melting Fire; but ſeizes upon the Nitre, which reduces the Phlogiſton of the Tartar as well as the

mineral Sulphur: for this Reaſon the mineral Sulphur is not intirely conſumed: And if it were, the Acid of it detained by the alcaline fixt Salt here produced with it, and joined with the Phlogiſton of the Tartar, would nevertheleſs make a copious *Hepar Sulphuris*, whereby a great Deal of the *Regulus* would be retained. This appears evidently, if you add to the Scoria half its Quantity of Filings of Iron, and melt it a ſecond Time: For then, the *Regulus* remaining in the Scoria, will ſubſide to the Bottom of the Cone. Likewiſe, a great Deal of *Sulphur Auratum* is precipitated, if this Scoria is edulcorated with warm Water, and Vinegar poured upon the Diſſolution. A great Quantity of reducible Flowers is alſo rejected during the Detonation. And as the Mixture muſt be put at ſeveral Times into the Fire, and muſt be left the longer in it, the Veſſel being mean while open; a great Deal of this volatile Semi-metal is conſumed, and on this Account there remains but a very ſmall Part of the *Regulus*, at the Bottom of the melting Cone.

PROCESS LXIII.

The Precipitation of Regulus *of Antimony, with Metals* (P. I. § 147. Coroll. 3.) *Iron is taken for an Example.*

APPARATUS.

1. PUT one Part of Iron not ruſty into a Crucible made thoroughly white-hot in a Wind Furnace. But you muſt chuſe Bits of Iron not very thick, for Inſtance, ſmall Plates, Nails, or even freſh Filings. When the Iron is perfectly white-hot, add to it, the double Quantity of crude Antimony at ſeveral Times, leſt the Veſſel ſhould break aſunder by the too ſudden Application of a cold Body: You will ſee your Iron diſſolved by the melted Antimony: This done, add to it at different Times, of

Nitre, or of any fixt alcaline Salt whatſoever, a quarter Part, with reſpect to the crude Antimony; leave all theſe Things in the Fire for a few Minutes more, that they may melt very thin together; then pour them into a melting Cone, in which, by ſtriking it, the whole reguline Maſs contained in the crude Antimony, will ſubſide: Separate the Scoria's which will be hard: Expoſe them to a free and ſomewhat moiſt Air, and in a few Days they will of themſelves fall into a Powder.

2. Put the *Regulus* a ſecond Time into the Crucible, add to it one quarter Part of freſh crude Antimony, cover the Crucible with a Tile, and melt the Matter with a Fire not violently excited: When the whole is in Fuſion, add at ſeveral Times one ſixth Part of Nitre, or very dry fixt alcaline Salt, and a few Minutes after pour out the Maſs well melted.

3. The *Regulus* may be melted a third or a fourth Time with a very little Nitre: This will detonate, and at the ſame Time aſſume a refractory Nature: If at laſt you uſe the ſtrongeſt Fire, your *Regulus*, when poured out, will be finally Marked with a Star, but a great Portion of it will be conſumed by the Nitre and the Fire in theſe laſt Fuſions.

The Uſe and Reaſons of the Proceſs.

1. If you precipitate *Regulus* of Antimony, with Metals (*Part* I. § 147. *Coroll.* 3.) you will have the Whole of it without any Loſs; but, it will be tainted by a conſiderable Mixture of the precipitating Metal: But, a greater Quantity of the Metal joins to it, as the Action of the Sulphur upon it is ſlower, and as the Sulphur itſelf melts more eaſily with the *Regulus* of Antimony. Thus, in every Precipitation by Fuſion of Metals by Means of other Metals, the precipitated Body partakes of the precipitating one, except Lead alone, to which the Iron that precipitates it never mixes; becauſe both theſe Metals do not diſſolve each other in the Fire. The firſt Scoria

which is produced in the preſent Caſe, is Iron diſſolved by the Sulphur of Antimony; for which Reaſon this Scoria is of a very hard Nature, and very difficult to be ſeparated from the *Regulus*. To make it ſeparate eaſily you muſt add an alcaline Salt, or alcaleſcent Nitre, whoſe Acid is expelled by that of Sulphur: This Alcali diſſolves the Scoria, and makes it ſoft and diſſoluble by the Moiſture of the Air. Likewiſe, the *Hepar Sulphuris* produced in the Operation does alſo efficaciouſly diſſolve the precipitating Iron, and retains it united to itſelf, leſt the Part of it which is diſſolved by the Sulphur ſhould again unite itſelf ſo eaſily to the *Regulus* of the Antimony.

2. A ſecond Fuſion is made with crude Antimony and Nitre, or with freſh alcaline Salt, to the End that the Iron remaining in the *Regulus* may be furthermore ſeparated. For Inſtance, the *Regulus* which is much more refractory in the Fire than the crude Antimony, is diſſolved by the Sulphur of it, and at the ſame Time this Sulphur meeting the Particles of the Iron contained in the *Regulus*, and having abandoned the reguline Portion of the Antimony, joins with them; when joined, making a lighter Maſs, it is caſt up at Top, and forms a Scoria, in which a great Deal of Antimony is adherent, for want of a precipitating Body. The Salt added over and above has the ſame Eeffect as N°. 1. But, it is eaſy to conceive, that in this ſecond Fuſion, the *Regulus* is tainted with ſome ſmall Quantity of Sulphur.

3. To conſume this Sulphur intirely, it is neceſſary ſeveral Times to repeat the Fuſion; which is not made ſo well with alcaline Salt, as with Nitre: For the latter being flung upon a *Regulus* boiling by the Violence of the Fire detonates with the Sulphur that lies hidden in it, and at the ſame Time becoming Alcaline by the Strength of the Fire, it aſſumes a refractory Nature, which is increaſed by a ſalt like Tartar vitriolate, which is produced by the Acid of the Sulphur, and the alcaline Part of the Nitre.

Nor is the pure Phlogiſton, that forms the *Regulus*, free from the Force of the Nitre: Wherefore, a great Deal of the *Regulus* is calcined, and, together with the very ſtrong alcaline Salt here produced, is changed into a Glaſs, which being intermixt with the Scoria's, is the Cauſe of their amber or ſaffron-Colour: This Colour is communicated to Glaſſes by Arſenick and the *Calx* of Antimony, unleſs they are burnt too long in the Fire. Thoſe who repeat the Fuſion ſeveral Times with Nitre, at laſt conſume the *Regulus* to no Purpoſe, becauſe that, which remains in the End, never becomes malleable. Nor does the Preſence of mineral Sulphur at all require a frequent Repetition of the Work; for, nothing of it can be ſhewed in a *Regulus* once or twice purified.

OF BISMUTH.

PROCESS LXIV.

The melting Biſmuth out of its Ore.

APPARATUS.

1. Biſmuth-Ore may be melted with the ſame *Apparatus* uſed for the melting crude Antimony out of its Ore (*Proc.* LX).

2. The very ſame may be done in the melting Furnace, if you ſet it upon its Bottom with the Bed, and a Recipient outwardly applied to it (*Proc.* XXXV). In this *Apparatus*, you muſt break your Ore in ſmall Bits, and mix it by *Strata* with Charcoal, or with very ſoft broken Pieces of Wood. But, your Bellows muſt be loaded with a very ſmall Weight, that their Blaſt may be very gentle; nay, the Fire may even be ſufficiently excited for this Fuſion without Bellows, by putting only the Cover and the Funnel at Top of the Furnace: For Biſmuth will not bear ſo great a Fire, to make its ſtony *Matrix*

turn to Scoria. The Ore being thus run down into the inward Bed, muſt be ſtirred now and then with a Poker, that the ſmall interſperſed Grains of Biſmuth may be driven out, and run into the outward Bed, where they join with the reſt into a *Regulus.* When the ſemi-Metal is melted, take away the Droſs, with a Sort of wooden Scraper or Hough: And removing the Body of the Furnace, take the Ore remaining in the inward Bed, and extinguiſh it in a Veſſel full of Water, and then waſh off and reject the ſmalleſt Particles, collecting only the larger Ones, to melt them together in a gentle Fire.

3. You may alſo run down Biſmuth in an earthen or an Iron-Veſſel. Fill this with your Ore broken in ſmall Pieces, and make a wood-Fire all round: And thus you will, by the ſame Method as before, eaſily obtain Biſmuth out of a fuſible Ore, eſpecially out of a rich one.

4. You may alſo beat your Ore to a very fine Powder, with the black Flux, Sandiver, and common Salt, in a cloſe Veſſel like the Ore of Lead or of Tin, and melt it in a middling Fire, having a Draught of Air: But, as this ſemi-Metal is deſtructible and volatile, you muſt, as quick as poſſible, apply to it that Degree of Fire which the Flux requires to be melted, and ſo ſoon as it is well melted, the Veſſel muſt be taken out of the Fire, and when it is grown quite cold, and broken, you will find your *Regulus.*

The Uſe and Reaſons of the Proceſs.

1. Biſmuth is found in its *Matrix's*, either pure and in a Semi-metallick Form, or in a State of Ore, when Arſenick is joined to it: And as this ſemi-Metal is at the ſame Time moſt fuſible; on this Account, it does not want the Aſſiſtance of any melting *Menſtruum*, or of any reducing Phlogiſton; but may be run down out of its Ore, by only a ſimple Fuſion, and with a gentle Fire. If there is any

ſmall Quantity of Arſenick in it, the free Air and Fire diſſipate it. But you can uſe this Fuſion, only with rich and very fuſible Ores.

2. If the Ore is very refractory, and the deſired ſemi-Metal lies hidden in a ſmall Quantity, within very narrow Interſtices, then a Fire ſomewhat ſtronger is required, that, being more attenuated, it may extricate itſelf: But, in this Caſe, it will be entirely diſſipated, unleſs you apply to it a ſmoaking, reducing Fire, which muſt be at the ſame Time moderate, and in ſome Meaſure confined from it. For as Biſmuth is eaſily reduced by the Phlogiſton of the Fuel of the Fire, it is alſo ſoon diſſolved into Fumes and ſublimed.

3. You will obtain a much greater Quantity of Biſmuth, if you melt your Ore with the black Flux, Sandiver, and common Salt, in cloſe Veſſels: The Reaſon of this is, that the *Matrix* of Biſmuth, or of its Ore, is ſooner diſſolved than vitrified by the Force of the Salts: Wherefore, the Particles of Biſmuth being then confined, may be more perfectly precipitated; whereas, on the contrary, a great deal of it remains in the Chinks of the *Matrix*, in the foregoing Eliquations; becauſe a *Matrix* of itſelf very refractory, is, by the Volatility of Biſmuth, hindered from turning to Glaſs with Fire alone. Beſides, the free Action of the Air, being excluded, and a reducing Body added, the ſame Quantity can never be diſſipated, as when the Air and Fire act freely upon it, and a little of a reducing Body comes to your Aſſiſtance. Moreover, Arſenick is moſt commonly joined in no ſmall Quantity with Biſmuth: But this (as will afterwards appear in the Proceſſes to be made with it) is reduced and precipitated, with ſaline reducing Fluxes, into a Semi-metallick *Regulus*, not unlike Biſmuth, more fixt than Arſenick itſelf, ſometimes volatile enough, which, nevertheleſs, meeting another Metal or ſemi-Metal, mixes with it, and is fixt.

4. The Cobalt of Arſenick (*Part* I. § 325), of almoſt every Kind, has ſomething of Biſmuth in it:

And as for the reſt, there is moſt commonly no other Difference, between the Ores of Arſenick and thoſe of Biſmuth, but the greater or leſs Proportion of either of them mixt with the other. But, when there is but a ſmall Quantity of Biſmuth, it cannot be run down with any Profit, though Biſmuth be not a Thing of the loweſt Value. But, when the *Caput Mortuum* of Cobalt remaining after the Roaſting of it, is melted with Flints and Pot-Aſh, to make with it the Glaſs called Smalt; a *Regulus* is produced much like Biſmuth, though different from it in ſome Meaſure. See *Part* I. § 407. *Schol.*

OF ZINK.

PROCESS LXV.

Zink (Part I. § 14.) *is ſublimed into irreducible Flowers.*

APPARATUS.

1. IF you put a few Ounces of Zink into a Pot, or a ſmall earthen Cucurbite, and place this Veſſel horizontally, or rather with its Orifice upwards, in a reverbatory Furnace, fitted for Diſtillations of Oil of Vitriol, or others requiring the ſtrongeſt Fire, and fit to it, by means of an Aludel, a large glaſs-Recipient, in ſuch Manner, that you may look within through its tranſparent Bottom, into the Cavity of the ſmall earthen Cucurbite; after having carried your Fire to a very great Degree of Brightneſs, you will ſee your melted Zink ſuddenly take a Flame of a green Colour, and at the ſame Time a very thick grey coloured Smoak ariſe, which will be puſhed forward into the Recipient, like Cobb-webbs fluttering in the Air, and cover the whole Inſide of it, and a little after hinder you almoſt entirely from ſeeing any further. After you have continued your Fire for an Hour or two; let the Veſſels grow cold,

and when you open them, a very thin Fume of the garlick-like Smell of Arſenick, will break forth, and vaniſh very ſoon after. The Recipient will be covered over on the Inſide, with a Coat of very ſoft, impalpable, and light Flowers of a bluiſh white Colour: But, the Aludel will be incruſtated, partly with the more ponderous blue Flowers, conſiſting of coarſer Grains, and partly with the ſolid Sublimate produced from the ſmall Drops of melted Zink entirely ſublimed, the grey Flowers of the deſtroyed Zink being every where interpoſed. You will find in the earthen Veſſel itſelf ſomething ſtill of the Zink covered and ſheltered as it were with a Bliſter, from being entirely burnt, or ſublimed: Which is the Flowers burnt, and almoſt half vitrified. If you uſe a Fire ſo gentle, as that the Zink may not take Flame; hardly any Thing will evaporate in Form of Zink, or of Flowers.

2. If you expoſe to a middling Fire, having a Draught of Air, two or three Ounces of Zink, in an open earthen Cucurbite, upon a ſtone Support, as one places a Crucible; Zink takes Flame much ſooner than in a cloſe Veſſel, and fills the whole Cavity of the Veſſel with very white Flowers like Locks of Wool: But, ſo ſoon as the Veſſel is full with theſe Flowers, ſo as that you can no longer ſee the Surface of the Zink; the Flame, which was very bright before, gradually diminiſhes, till it at laſt ceaſes entirely; ſo that the Zink can no more be brought to a Deflagration, not only with the ſame, but alſo with a ſtronger Fire. If then you take away the Flowers with a ſmall Iron Ladle, and free the Surface of the melted Zink at the Bottom of the Veſſel, from thoſe which covered it; a bright Flame is again produced as before, and in a few Minutes the Cavity of the Veſſel is filled with Flowers of the ſame Kind: If you continue this Work in the ſame Manner; at laſt all your Zink, provided it was pure, is reſolved into a great Quantity of very white Flowers; nor does a great deal of it fly away, unleſs the Fire acts too

melting Veſſels, the Orific
equal Diameter. Then ad
Orifice of one of the two P
it may indeed reſt upon the
out too much all round: L
ral Holes bored here and th
Pavement of the Hearth;
about two Inches high; the
plate. Put upon this Plate
Capacity, and full of a *Ma*
cury: Next, cloſe theſe Veſ
inverted: Stop the Joint
which muſt be applied pretty
the inferior Pot in Aſhes and
cloſe round it, and heaped
Put upon theſe Things a mo
nue it for about half an Hou
may grow ſlightly red-hot.
hidden in the Matrix will
which being ſtopt above, will
condenſated: They are preſe
from the too great Heat: For,
Degree of Heat whereby the
in the Form of Vapours, or b
when once condenſated; unleſ
fectly impriſoned in the Veſ
not to be able to perſpire:
grown cold, open them, and
contained in the inferior Pot,
of Mercury diſperſed here an
to the Sides of the Veſſel, may

The Uſe and Reaſons

1. Mercury intirely volatil
Diſtillation in a moderate Fi
tion, and even without any
geſting Fire is continued
Diſtillation is performed w

violently. But the Flowers apply themſelves preſently to the Sides of the Veſſel, and even adhere to the Surface of the Zink itſelf; nor can they afterwards be further changed, or rendered volatile, by the ſame Degree of Fire by which the Zink has been burnt and ſublimed; ſo that by this Method you may prepare Abundance of Flowers of Zink in the moſt convenient and neateſt Way. Nevertheleſs, you may alſo adapt Aludels, or only cylindrical Segments, to the Orifice of your Veſſel: By which Means you will obtain a little more abundant and more ſubtile Flowers. But, that the Surface of your Zink may be now and then freed from the Flowers that cover it, and the whole Cavity of the inferior Veſſel be rendered free, it is proper to make a Hole at the Side of it, ſo large as that you may take out through it the Sublimate, with a ſmall Ladle, as was ſaid before.

3. When you apply ſuddenly to pure Zink the ſtrongeſt Fire with a Draught of Air; the whole of it vaniſhes: Nor is it confined by the Crucibles being ſtopt with Lute. For Inſtance, if you put an Ounce of pure Zink into a ſmall Crucible covered with a ſmaller inverted one, ſtopping all the Joints well with common Lute, and put it into a wind-Furnace, ſurrounding the whole Veſſel with Charcoal and burning Coals, and excite the Fire to its utmoſt Degree, by applying the Bellows to the bottom-part of the Furnace, and continue it for half an Hour, when afterwards you take out the Veſſel, you will not perceive therein the leaſt Footſteps of Zink, or of the Flowers of it. The very ſame Thing happens with the other Semi-metals, though not ſo quickly.

4. If you mix the white Flowers of Zink, or the blue and grey ones calcined to a white Colour in a middling open Fire, with common reducing Fluxes, ſuch as are the black Flux, and the white (*Part* I. § 162. &c.) adding fluxing Salts to them, they cannot afterwards by any Means be reduced in the

ſame Manner as the other Metals and Semi-metals, by being expoſed to a melting Fire. Nor has any Method hitherto been invented, or communicated at leaſt by the Inventor, whereby the Flowers of Zink may be reduced to a Semi-metallick State: Since they rather are fixt ſo far in the Fire, as to be vitrified with Fluxes.

5. When the grey and blue Flowers are melted with ſome very fuſible Salt, though this be impregnated with none or at leaſt very little Phlogiſton, you may obtain out of them, I ſhall not ſay, reduce from them, a few Grains of Zink. For Inſtance, if you mix by Trituration the Flowers juſt mentioned, with Sandiver, or the cauſtick alkaline Salt * which is prepared out of the inſpiſſated Lye of Pot-aſhes and Quick-lime, and expoſe them in a Crucible, to a Fire not greater than is neceſſary to melt the Salt well, and then take them preſently out of the Fire, and fling the Crucible with the Salt grown cold into a clean Baſon full of warm Water, you will find, after having waſhed off the Salt and the lighteſt Droſs, a few and very ſmall Grains of Zink, moſt commonly covered with yellow Cruſts, precipitated here and there at the Bottom of the Veſſel, and not to be collected without a tedious Labour. Theſe Grains of Zink, if not pretty large, hardly melt into a *Regulus*, but periſh intirely, being reſolved by the Fire into ſmall Flames and Flowers. But, you muſt not for this Purpoſe uſe the black or the white Flux, becauſe they require ſo great a Fire to be melted, that the ſmall and widely-diſperſed Particles of the Zink are burnt much ſooner than they can be precipitated by the concomitant Matters melted ſufficiently thin: Which is very plain from the ſmall coloured Flames and Flowers that break forth. Nor does the above-mentioned very acrid Salt bear the Addition of the Phlogiſton; nay, when already

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* The cauſtick Alkaline Salt here mentioned to be made of Soap Lees and Lime, is commonly known by the name of *Lapis Infernalis*, the Cauſtick ſo generally uſed by Surgeons.

melted, if you add the leaſt Fat to it, it immediately grows ſolid, and requires a Fire equally ſtrong as the black Flux does, to be brought again to a State of Fuſion: And this ſeems to be the Cauſe why Grains of Zink ſo difficultly run into one reguline Maſs; becauſe this Salt, while it abſorbs the Phlogiſton wherewith Zink is full, forms thoſe ſmall yellow Cruſts round the Grains of the Zink, which Cruſts are difficult to be melted.

The Uſe and Reaſons of the Proceſs.

1. The Reaſon is plain from this ſingular Property of Zink, why we try in vain, by Precipitation by Fuſion, with the Aſſiſtance of ſaline, oily, reducing Fluxes, to produce Zink from its Ores hitherto known in *Europe*, in the ſame Manner as we commonly uſe for other Metals and Semi-metals. It is as plain, why it can much leſs be collected in the Beds of the Furnaces (*Proc.* XXXIV), by a Stratification with Charcoal, by Means of the Vitrification of the terreſtrial Bodies adherent to it, and of a violent Fuſion, excited with the Blaſt of Bellows; but ought rather to be collected and ſublimed (*Part* I. § 409. *&c.*) in Places pretty cold, and not much expoſed to the Action of the Wind.

2. Mean while, the Zink that lies hidden in Ores, or other compound factitious Bodies, betrays its Preſence by the Flowers which it emits from itſelf when urged by a ſtrong Fire, and by the golden citron-Colour it gives to Copper. For both theſe Effects were never produced by any other known Body, as much as can be collected from all Experiments: Wherefore, we may as ſurely conclude the Preſence of Zink from them, as we ſurely conclude that of Iron from the Action of the Magnet.

3. A ſtrong open Fire, and ſublimatory *Apparatus* (*Part* I. § 462), are required to collect theſe Flowers: However, you muſt with great Care avoid the too-violent Paſſage of the Air through the Furnace, and the leaſt Blaſt of it through the ſublima-

tory Pots: For the ſofteſt and lighteſt Flowers are diſſipated by the leaſt Motion of the Air. Therefore, it is proper to uſe large Aludels: By this Method you will obtain Abundance of Flowers out of Calamine, eſpecially if you break it into ſmall Bits of the Size of a Pea, and lay it in *Strata* with Charcoal; when thoſe are conſumed, you collect it out of the Aſh-hole, and put it in again with freſh Charcoal. Thus it is ſometimes for a very great Part reſolved into Fumes and Flowers, according to its different Degrees of Purity. Theſe Flowers firſt come forth bluiſh, then more and more grey, and white at laſt. They are vaſtly like the Flowers produced out of Zink itſelf and called *Nihil album*, *Nihil gryſeum*, according to the Difference of the Colour, which nevertheleſs depends on the Impurities mixt with them, or (if the Operation has been neatly performed) on very ſmall Portions of Zink, not yet deſtroyed, or from both Cauſes. For, Zink may indeed be collected out of them, according to *Appar*. N°. 3. and if they are again made red-hot for a few Minutes, they grow perfectly white; becauſe Zink is not very conſtant in the Fire. They are alſo called *Pompholyx*: And we ſhall leave to others the Care of finding out, whether it is the ſame as the *Pompholyx* of the Ancients, and whether the *Spodium* of the *Greeks* finds alſo its Place here: But, whoever has a Mind to ſift theſe Matters, let him not undertake it without having Recourſe to Experiments; leſt he ſhould afterwards give us Words for Things; nor pretend to reconcile the various Opinions of all the Authors, many of whom have ſtuck to Words much more than to Things.

4. *Pompholyx* and *Nihilum* (*Nil*) are indeed ſold in Shops, but ſeldom genuine: For, as they are collected in ſmall Quantity, they are adulterated in a thouſand different Manners: While the ſeveral Kinds of light white Marls, the Parget made of burnt Spaad, and the white, fat, Boly Earths, ſuch as the Fullers-earth, the Heſſian-earth, &c. or even

compound Maſſes, made ſeveral Ways with theſe, both by Nature and Art, are ſold for the white *Nil* of the Shops: See *Henckelli Pyritolog.* p. 581. Which Fraud is not always eaſily detected: Nevertheleſs, it is often known from too great a ſpecifick Gravity, from an exceſſive Roughneſs, and from the Want of a quick Diſſolution in Acids. But, it is better for him who wants to have true genuine *Nil*, to prepare it himſelf.

PROCESS LXVI.

The Cementation and Fuſion of Copper with Zink-Ore.

APPARATUS.

TAKE of Zink-Ore, for Inſtance, of Calamine reduced to Powder, *one Part and a half*, and as much of comminuted Charcoal; grind them together, and moiſten them ſlightly with Water: Fill any melting Veſſel with this Mixture, put between and at Top Plates of the pureſt Copper *one part*, and again cover them with Charcoal-duſt, and put the Whole in a wind-Furnace, covering it with a great Quantity of Charcoal; light them by ſlow Degrees, and then increaſe the Fire, to make the Veſſel grow white-hot: When you ſee a Flame tinged with a grey, bluiſh, or purple Colour; try here and there with a ſtrong Iron-Wire, whether the Copper is melted under the Charcoal-duſt: Which is done with a much leſſer Fire, than Copper alone requires for the Fuſion of it: Then moderate your Fire, that it may not be too violent: Finally, having continued the Fuſion a little longer, let the Veſſel be taken out of the Fire, that it may cool of itſelf, or let the melted Maſs it contains, if conſiderable, be poured out into a dry and middling-warm Veſſel: You will find, when you break the Copper, that it is tinged with a golden Colour, and that the Weight of it is increaſed a conſiderable Quantity, which is ſometimes one quarter or one third Part of the Weight of the Copper made uſe of, its Malleability remaining perfect in the Cold: But the more it grows hot in the Fire, the more brittle it becomes; ſo that, when it grows middling red-hot, you will eaſily break it into ſmall Bits with a wooden Mallet, or if it is handled roughly, having then loſt all its Tenacity.

2. If Calamine, or any other Body containing Zink, and to be tried by this Method, is full of a great Quantity of Lead, or of ſome other Metal not ſeparable from it; it is proper, that the Mixture of it with pulverized Charcoal made as before (N°. 1), be ground very fine, that ſome Lute be mixt with it, and that it be ſtrongly compacted and crammed into a melting Veſſel, to the End that, the Plates of Copper put at Top being melted, they may not get to the Bottom: Then, you muſt put a good Quantity of Charcoal-duſt upon your Plates of Copper, and do the reſt as before: Likewiſe, melt the Copper in a Fire much gentler than when it is alone; and it will be tinged, though with a Colour ſomewhat paler, nor will the Weight of it be ſo much increaſed.

The Uſe and Reaſons of the Proceſs.

1. In this Proceſs the Copper is penetrated by the Zink, in form of a Vapour, and the Zink is fixt in it: Which plainly appears, becauſe when you ſtop the Paſſage of the Copper, by putting Lute between, to keep it from running down into the Mixture at the Bottom of the Veſſel, nevertheleſs its Conſiſtence, Colour, and Conſtitution change in the Fire, and its Weight increaſes, inſomuch that it is certain the ſublimed Mater has produced theſe Effects. The Charcoal-duſt does alſo prevent the burning of the Copper, and hinders the Zink received by it from being again burnt and diſſipated. For, if you melt tinged Copper in a Crucible, without any Addition, it takes a bright Flame almoſt like Zink itſelf, and ſpreads Abundance of white Flowers tinged here and there with a Citron-colour, which ſeems to

proceed from the Copper carried away along with them, being otherwiſe like the Flowers produced (*Proc.* LXV): But, in this Caſe, a great Part of the Weight of the Copper is loſt at the ſame Time, and the Colour of it grows every inſtant worſe and worſe. For this Reaſon, when you tinge Copper with Calamine, to get Profit by it, you muſt try by Experiments, what Degree of Fire you are to uſe, and in what Time the Copper acquires the greateſt Weight, and aſſumes the fineſt Colour: For, it is plain to the Eye, that a great deal of it alſo vaniſhes in Form of a thick Fume. However, it is obſervable, that Braſs or Copper impregnated with Zink, being made middling red-hot in the Fire, is not ſo eaſily calcined as pure Copper. There are alſo a great many Differences in the Calamine: For, a Quantity of ſome Calamine increaſes the Weight of Copper, more than the ſame Quantity of ſome other does. The Beauty and Malleability of the tinged Metal are likewiſe different: For, ſome Calamine affords a great Deal of Lead and Iron; whereby the Copper is ſpoiled and rendered pale and brittle; though the Weight of it is very much increaſed at the ſame Time. There are even ſome Species of this Stone, that require a previous Roaſting, whereby a great Part of it muſt be diſſipated, before it is rendered fit for this Uſe; while others may be immediately made Uſe of.

2. There are, beſides the Calamine, many compound artificial Bodies, which likewiſe tinge Copper with a yellow Colour, and increaſe the Weight of it: Such as are the *Cadmiæ Fornacum*, or Tutty (*Part* I. § 89); but, all Kinds of Tutty are not ſo, but thoſe only which proceed from Zink-Ores, or from compound Metals in which Zink enters: Of which all that has been ſaid of the Calamine is equally true. A moſt elegant and pure Kind of it, is the Tutty uſed in the Apothecaries Shops: It is very ponderous and ſolid, reſembling cylindrical Segments by its Figure, rendered convex and hollow by the Obſtacle to which the Vapours have applied themſelves, granulated on

the Outſide, of a bluiſh Colour, ſmooth within, and yellow. Nor is it dubious, that there are ſeveral native Minerals, or ſeveral Kinds of Tutty produced from them, that would have the ſame Effect: But, it is highly probable, that their Nature is hitherto unknown to us, becauſe the Examination of them has been neglected to this Day.

3. Copper tinged in this Manner, when it preſerves its Malleability, is called *Braſs* or *yellow Copper*; and as it is, by its Beauty, eaſy Tractability, and long Duration, very fit to make Utenſils, and the metallick Maſs is ſo eaſily increaſed in the making of it; on this Account, a very great Quantity of it is made in ſeveral Places, when the neceſſary Ingredients may be conveniently prepared.

4. The Flowers, which are collected during the making of Braſs, or the melting of it a ſecond Time, and the roaſting of the Calamine, as alſo the Flowers of Zink itſelf not yet intirely burnt; likewiſe, all the Sublimates proceeding from Bodies of the ſame Nature, being cemented in the ſame Manner as the Calamine, that is, with Charcoal-duſt and Plates of Copper, and melted, make Braſs of the beſt Kind. But, the ſame being burnt in a ſlow Fire, are ſo fixt, that in cloſe Veſſels, and a ſtrong Fire with a Draught of Air, they turn to a yellowiſh Glaſs; as is well obſerved by *Henckel* concerning Zink; however, he would, it ſeems, have this underſtood only of the Flowers of it: See *Proc.* LXV. *Appar.* N°. 4.

5. It is a wonderful Thing, that Zink itſelf being plainly melted with Copper, robs it of all its Malleability: As may be experienced in the making of Prince's-metal (*Part* I. § 88): While being at the ſame Time applied by way of Vapour, and lying hidden in the Calamine, in the Sublimates, and in the Flowers, it does not take away the Malleability. If this does not proceed from the Concurrence of Lead, according to the Opinion of the Author juſt quoted, or from a very intimate Junction of the Zink and Copper, the Reaſon of it is ſtill a perfect

Secret. Nor is the Reaſon yet ſufficiently evidenced, why a great Quantity of excellent Calamine requires a previous Roaſting, before it can be uſed for the making of Braſs; unleſs you have a Mind to render this Metal leſs fine and malleable. Which *Phænomenon*, as well as a great many others falling under the Hands of one buſied that way, are well worthy of being inquired into.

OF MINERAL SULPHUR.

PROCESS LXVII.

The Diſtillation of Sulphur out of the Pyrites, and other ſulphureous Minerals.

APPARATUS.

BEAT the yellow Pyrites, or any other ſulphureous Mineral, to a coarſe Powder, put it into an earthen Retort, or into a glaſs-one coated with Lute, having a long large Neck, and perform the Diſtillation in the ſame Manner as (*Proc.* LVIII.) was preſcribed about Mercury. But, you are to obſerve, that, if this Mineral is ſo refractory in the Fire that it does not grow ſoft when made middling red-hot, you may make an Experiment with a greater Quantity of it exceeding two or three Pounds, and increaſe the Fire more quickly, and thus perform the Operation in a ſhorter Time. Of this Kind is the yellow martial Pyrites, which is chiefly the Ore out of which almoſt all the common mineral Sulphur is got (*Part* I. § 316, 347). But, if it grows ſoft when it begins to be red-hot, and the Ore is inclined to melt, you muſt put a ſmaller Quantity of it into the Retort, and manage the Fire more gently, whence the Diſtillation laſts a longer Time: This the Pyrites of Copper, or the yellow Copper-Ores (*Part* I. § 369) do require, as well as the common Lead-

Ores; for ſo ſoon as they melt, the Exhalation of the Sulphur is in cloſe Veſſels almoſt intirely ſtopt. Nevertheleſs, this Inconvenience may be remedied in ſome Meaſure, by interpoſing ſome refractory Body, that exhales no Sulphur in the Fire, though it muſt not abſorb or corrupt the Sulphur itſelf; ſuch is pure Sand waſhed clean, and of the Nature of the Stone called *Quartz.* But you muſt avoid all Stones of the lime, chalk, or ſpaad-Kind.

2. When the Retort has been middling red-hot for an Hour or more, let the Veſſels grow cold: All the Sulphur cooled by the Water will adhere to the Extremity of the Neck of the Retort, from which it muſt be melted off, by a gentle Heat that does not kindle Sulphur; or you may take it out by breaking or cutting off the Neck; then weigh it.

The Uſe and Reaſons of the Proceſs.

1. As there are in Minerals many volatile Matters beſides Sulphur; it is eaſy to conceive, that it is not always got pure out of them, but often joined with other volatile Subſtances, that taint it; which may be judged with ſome Probability, from its Colour: For pure ſublimed Sulphur is always of a fine Yellow ſomewhat deeper than the Citron-colour; but, its being of a red Dye ſhews that Arſenick has been ſublimed along with it: But, though Mercury, when ſublimed with Sulphur, does likewiſe give it a reddiſh Colour, it ſeldom mixes with it. However, if this ſhould be the Caſe, you may eaſily diſtinguiſh it from the ſtriated Figure of the broken Sublimate, from its great Weight, and from the Place to which it has applied itſelf during the Sublimation; for, where Cinnabar applies itſelf, there can remain no Sulphur, nor any Arſenick.

2. By this Diſtillation, a moſt conſiderable Quantity of Sulphur may be got out of the Pyrites: but there remains a very ſmall Quantity of the metallick

Earth of Copper and Iron joined together, which muſt at laſt be ſeparated by Means of a very ſtrong, open, long-laſting Fire, and by other Remedies already mentioned in the Proceſſes about theſe Metals.

3. If you want the Apparatus neceſſary for this Proceſs, or care not to give yourſelf ſo much Trouble; you may have Recourſe to a plain Roaſting; and put, for Inſtance, one docimaſtical Centner into a Teſt covered with another Teſt inverted, and roaſt it under the Muffle of the docimaſtical Furnace, or in a gentle open Fire ſlowly applied, like an Ore to be prepared for Fuſion: In which you are to take care, that the remaining *Calx* be not brought to a Fuſion, or rendered clammy, by a greater Heat than it can bear: This done, if it ceaſes to ſpread an unpleaſant ſulphureous Smell; let it grow cold, and weigh it, to know how ſhort it falls of one Centner: Which Deficiency will be the Quantity of Sulphur that was in the Ore. But, it is proper that you ſhould know, either from the outward Appearance, or from the Smell which your Ore emits, that it is indeed ſulphur Ore, or that Sulphur is at leaſt prevailing in it; becauſe all volatile Subſtances occaſion a Diminution in the Weight of Ores, by roaſting: Nor will you be as ſure of the Purity of your Sulphur, and of Courſe of the Quantity of it when rectified, as if you had collected the volatile Part itſelf.

4. You may know bituminous Minerals (*Part* I. § 318. *&c.*) from the Flame which they take in the Fire, from a thick ſooty Smoak, which mineral Sulphur never emits, and from their offenſive or pleaſant Smell: They may alſo be tried with greater Exactneſs, by Diſtillation out of a Retort, in ſeveral Degrees of Fire.

PRO-

PROCESS LXVIII.

The rectifying, and ſubliming crude Sulphur into Flowers.

APPARATUS.

PUT your Sulphur again into a Retort, having a wide-open Neck cut off ſhorter; that it may not be eaſily ſtopt, nor the Extremity of it reach the Water in the Recipient: Let the Joints be ſtrictly cloſed with Lute, and, with the ſame *Apparatus* as in the foregoing Proceſs, repeat the Diſtillation, which may alſo be very well made in the Sand-bath. But, you muſt uſe a Fire much gentler than in *Proc.* LXVII; nor muſt the Veſſel be red-hot in the End; but you muſt continue the ſame Degree of Fire, by which the upper-Part of the Recipient which is void of Water is darkened, and the Sulphur begins to diſtil from the Neck of the Retort; becauſe Sulphur, once expelled out of its *Matrix* by a ſtrong Fire, when alone, cannot bear the heating red-hot of the Veſſel: The Sulphur will diſtil pure; becauſe it has depoſited at the Bottom of the Retort, what it had brought along with it the firſt Time, from the fixt Part of the Ore which is metallick, and from the Arſenick (unleſs it is urged by too violent a Fire) becauſe a Reſidue more fixt than Sulphur remains, which fixes itſelf more ſtrongly with fixt Bodies. This Reſidue is called Scoria of Sulphur, in German Schweffel-ſchlacke, or Droſs of Sulphur.

2. If you will have very pure Flower of Sulphur, put Sulphur into a wide Cucurbite, or an Iron-Pot; put upon this an Alembeck, or another Veſſel inverted and very large, and ſtop the Joints with Lute: Then, bury the inferior Veſſel that contains the Sulphur ſo deep in a Sand-bath, that the Sand may be about as high as the melted Sulphur; or

put ſmall burning Coals round the Veſſel, as it ſtands upon the Pavement of the Hearth. Let the Heat you apply be not greater than what is required to melt the Sulphur; and continue it ſuch for ſeveral Hours, that is, according as the Quantity of Sulphur is great, and the Veſſel wide: All which Things muſt be determined from Experience. You may alſo try whether the Sulphur is melted, and how much of it remains; by boring a ſmall Hole in the Top of the Alembeck, or in the Bottom of the upper-Veſſel, not exceeding the Size of a Pea, through which you may introduce an Iron-Wire, to the very Bottom of the Veſſel that contains the Sulphur. However, take as much Care as poſſibly you can, not to blow any Air in with your Mouth, through the Tobacco-pipe, if you make this Trial with one: For, if the Fire is a little too ſtrong, the Surface of the melted Sulphur immediately takes Flame, and by this Means the Vapours of it moving upwards, break the Veſſels aſunder with great Noiſe, and with ſome Danger to thoſe that ſtand by. If the greateſt Part of the Sulphur is ſublimed, remove the Fire, and when the Veſſels are cooled a little and then opened, you will find in the upper-one, and in the Brink of the inferior, light, ſoft Flowers of Sulphur, of a fine yellow Colour, having the Characteriſticks of perfect mineral Sulphur, and made perfectly pure by Sublimation. There remains at the Bottom the impure Sulphur, which muſt be taken out of the Pot ſtill warm; becauſe it adheres ſtrongly to it, when grown cold.

The Uſe and Reaſons of the Proceſs.

1. Sulphur, when it is for the firſt Time expelled out of the pyritoſe Ore, being agitated by a ſtrong Fire, carries ſome Copper and Iron away with it: But, a greater Quantity of theſe Metals diſtil along with the Sulphur, as the Ore is more arſenical; becauſe Arſenick is more rapacious than Sulphur, and

paſſes with the Sulphur, chiefly in the End of the Diſtillation, when a ſtronger Fire is uſed. This appears plainly, when you urge with a ſtrong Fire the Reſidue which remains in the Retort after the rectification; for then a tranſparent red Arſenick, and a red and yellow Arſenick, are ſublimed and come over. The *Caput Mortuum* which then remains, being roaſted in a cloſe Crucible, in a violent Fire, is in great Part attracted by the Load-ſtone applied to it, and when you extract a Quantity of it ſomewhat greater, it may with the white Flux, Glaſs, Sandiver, or Borax, be reduced into a *Regulus* of Iron (*Proc.* LIV.) but brittle, and ſtill containing a little Sulphur. The Copper betrays itſelf, when you roaſt gently the *Caput Mortuum*, then expoſe it to the Air for ſome Days, and then extract it with Water: For Calx of Copper may ſometimes be precipitated out of this Water, by putting in it Plates of pure Steel, which Calx muſt likewiſe be reduced to a *Regulus* (*Proc.* XXXVIII). As then this is done in cloſe Veſſels, and in a ſlow Fire gradually increaſed, it is ſelf-evident, that the ſame ſucceeds ſtill much better in an open, ſtrong Fire, ſuddenly applied, ſuch as is uſed by Aſſayers in the roaſting of ſulphureous, pyritoſe, arſenical Copper-Ores, of which we have ſpoken (*Proc.* XXXIX). But there does not remain an equally great Portion of *Caput Mortuum* from all Sulphur: But if Sulphur is expelled out of a ſmall Quantity of Ore that has once undergone a ſlow gentle Fire in a Retort; a very ſmall Portion of it is gotten: You obtain more of it, when a greater Quantity of Sulphur is expelled haſtily.

2. It has been imagined that there were ſeveral different Species of Sulphur, from the ſeveral Mixtures of theſe heterogeneous Matters: For all pure Sulphur is ever one and the ſame. For Inſtance, *the golden coloured Sulphur both tranſparent and opaque, the red Sulphur, the orange-coloured one, the ruby coloured Sulphur, and the ruby coloured Arſenick*, are nothing but Sulphur and Arſenick

mixt in different Proportions, and called by different Names. Likewiſe, the white, grey, and aſh Colours, *&c.* of Sulphur, depend upon the various Mixtures of Earths, partly metallick and partly unmetallick, with the ſame: Its very Conſiſtence is on the ſame Account changed to ſuch a Degree, that you can hardly judge from its outward Appearance, that it is for the greateſt Part Sulphur. This may be ſeen in the Sulphur, which, during the Roaſting of pyritoſe Ores made in a half ſuffocated Fire, runs ſometimes between the Bits of the Ore, and being collected when grown cold, is called in German Tropf-ſchwefel. *Sulphur vive*, or native Sulphur, is likewiſe found under various Forms. But you will eaſily find out by a gentle rectifying, what Body is mixt with the Sulphur in any Caſe whatever.

3. Whenever you rectify and ſublime Sulphur, it does not always ſuffer an eſſential Change; but remains uncorrupted in a cloſe Fire: But, when oily, fat, alkaline, and ſuch like Matters are joined to it, the Texture of it is deſtroyed. The combined Actions of too free an Air and of the Fire, deſtroy it: Beſides, in an open Fire, the inflammable Part of it takes Fire, and is conſumed. Wherefore the acid ſaline Part being a ſecond Time diſingaged is by the burning Phlogiſton reſolved into a moſt ſuffocating Fume, and again is very greedy of Water, which it intirely rejected in its Conjunction with the Phlogiſton. Whence, this Acid may then be alſo very well collected by Means of Water or of its Vapour, not being intirely diſpoſed of itſelf to gather into large Drops, and apply itſelf to the Sides of the Veſſels. This acid Fume of inflamed Sulphur, is commonly collected, by putting a Bell or a large Alembick over it, and is called *Spiritus Sulphuris per Campanam*, Spirit or Oil of Sulphur by the Bell. But it is moſt conveniently collected by the following *Apparatus*. Take a Cucurbite, as large as you can find it, not yet cut off at Top, and with a hard, cutting, ſharp Flint, mark in the Belly of it a ſquare,

oblong Figure, four Inches broad, and three Inches high, dextrouſly applying to it the acute Angle of the Stone in ſuch Manner, that it may in all its Tract ingrave a deep Furrow in the Glaſs: This done, touch every Point of the ſaid Furrow, with a ſtrong red-hot Iron Wire: By this Means, you will cut off from the Cucurbite, a Piece of Glaſs like the circumſcribed Figure. Put this Cucurbite under a Chimney that carries Smoke well, and in ſuch a Situation, that the Hole may be forwards, and the Cucurbite inclined backwards a ſmall Matter, and pour into it one or a few Ounces of warm Water: Then introduce a ſmall ſhallow wide China-Veſſel full of pure Sulphur, through the Aperture made in the Belly of the Cucurbite, and ſet this Sulphur on Fire with a Thread dipt in Brimſtone: When the whole Surface of it is on Fire; put a Plate of Lead againſt this Hole, that it may not admit more Air than is neceſſary to maintain the Flame. The acid Spirit of Sulphur will apply itſelf to the Side of the Cucurbite, made moiſt by the warm Water, and, running again to the Bottom, it will mix with the Water, which being kept warm by the Contact of the Veſſel in which the Sulphur burns, and ſpreading Vapours, diſpoſes to a Condenſation the acid Spirits that are expelled. But the Sulphur that is burning in a free Air, commonly contracts, at length, a ſmall Cruſt ariſing from the heterogeneous fixt Matters, ſomewhat hard, which hinders the Flame from further conſuming the Sulphur: Therefore this Cruſt muſt be removed about every Quarter of an Hour, if the Sulphur is not perfectly pure: Which done the Flame is again revived. Nay, it is alſo extinguiſhed by the Acid, which the half ſuffocated weak Flame of the Sulphur has not been able to diſſipate, there remaining in the Surface of the Sulphur grown cold ſmall Drops of a very acid Nature. If you find that this is the Caſe, you muſt immediately add freſh Sulphur, and admit a greater Quantity of Air: Otherwiſe the Flame once extinguiſhed, is very difficultly kindled again. You put in freſh Sulphur with a ſmall Iron-Ladle, with which you muſt alſo remove the Filthineſs that has ſucceſſively gathered and been introduced along with the Sulphur. Do the ſame conſtantly for one or ſeveral Days, till you have gathered the deſired Quantity of Spirit. It will be as ſtrong as if it had been collected without Water, and even in greater Quantity. What Methods and Operations ſoever you may uſe for the collecting of Spirit of Sulphur, you will never hinder the greateſt Part of it from evaporating, unleſs you will have it diluted in a great Quantity of Phlegm, or fixt in ſome alkaline Body or other, from which you will hardly ſeparate it with any Profit.

4. You may very well find out with a fixt Alkali, the Proportion in which the Acid and the Phlogiſton are combined in mineral Sulphur; and ſeparate them with the ſame fixt Alkali, in the following Manner. Take of very pure Flowers of Sulphur, one Part, of very dry pot-Aſh beaten to a very fine Powder in a warm Iron-Mortar, two Parts: mix them; fill a Crucible with this Mixture, cover it with a Tile, and put it into a Fire of a middling Strength. The Mixture will ſoon melt; pour it next into a dry Iron-Mortar, and with all poſſible Care ſcrape off what adheres to the Veſſel; then beat the whole to a Powder: Divide this into two equal Parts in a Pair of Scales: Roaſt one Part of it in a clean earthen flat Veſſel, not glazed, firſt with a gentle Fire, which muſt be increaſed more and more, till the Veſſel grows middling red-hot; ſtir it now and then with a Tobacco-pipe, taking great Care mean while, that no Aſhes fall into it; leſt the Weight ſhould be falſly increaſed: If the Salt grows quite white, and no
er emits any Smell, it is a Sign that the Phlo-
n is diſſipated: The acid of the Sulphur will ad-
o the remaining fixt Salt, with one Part where-
has turned to a Tartar vitriolate, out of which
annot be expelled by Fire alone. Weigh the

remaining Salt. Diſſolve the other Portion of this Liver of Sulphur in a glaſs Veſſel, with treble the Quantity of pure Water: There will remain a brown Sediment, which will be Sulphur not quite diſſolved by the Alkali: Pour upon this Solution the ſtrongeſt Spirit of Vinegar drop by drop, a white Powder will be precipitated, which is called *Lac Sulphuris*, or Milk of Sulphur: Stir up this Liquor, and pour it quite turbid into a filtrating Paper; when it is all gone through, pour again upon it Spirit of Vinegar drop by drop, that in Caſe more of the *Lac Sulphuris* is again expelled, it may be joined to the foregoing, by repeating the Filtration: What gathers in the filtrating Paper being dry, if you diſtil it out of the Retort, it will afford Sulphur (*Proc.* LXVII.) Thence it appears, how much Sulphur was hidden in the firſt Portion before the Roaſting. But as the Acid of the Sulphur remained alone in the firſt Portion, after the inflammable Part was diſſipated, it is certain that the Exceſs of the Weight of the extracted Salt, by which this ſurpaſſes the Half of the Weight of the Alkaline Salt employed, proceeds from thence, and this Exceſs of Weight ſhews of Courſe, how much Acid there is in the Sulphur which you have got by Precipitation and Sublimation. Thus you find that the Acid is about fifteen Times more weighty than the Phlogiſton, as has been demonſtrated by Dr. *Stahl.* But, as during the Fuſion of the Liver of Sulphur, not only Part of the pure Sulphur is diſſipated, but there is alſo an unpleaſant Smell perceived, which is different from the Odour of Sulphur, ſuch as is emitted in the ſubſequent Roaſting of the Liver of Sulphur; we are hereby informed, that Part of the Phlogiſton having left its Acid, is at that Time diſſipated, and that on this Account more Acid is attributed to the remaining Sulphur expelled with Vinegar and purified by Sublimation, than it has in reality. Therefore, it is proper, that you ſhould uſe pot-Aſh made perfectly pure, and try the *Caput Mortuum* remaining after the Sublimation of the *Lac*

Sulphuris, whether and how much Tartar vitriolate it contains; which is found out by Edulcoration with warm Water, and by the Diminution thus made in the Weight of the dried Reſidue; becauſe the Tartar vitriolate being already produced in the Liver of Sulphur, would remain with the *Lac Sulphuris*, in the filtrating Paper, as a Salt very difficult to be diſſolved: Therefore, as much Acid as is adherent to ſuch a Weight of Tartar vitriolate, ſo much are you to ſubſtract from the Increaſe of the Weight.

5. Mineral Sulphur may be produced by Art ſeveral Ways, out of any Acid and Phlogiſton whatever. This is moſt conveniently performed by *Stahl's* Method, as follows: Mix with Tartar vitriolate, in order to facilitate the Melting of the refractory Salt, an equal Weight of Pot-aſh, to which you muſt ſlightly mix one eighth Part of ſoft pulverized Charcoal. Put this Mixture at ſeveral Times into a red-hot Crucible, which muſt be covered with a Tile, leſt a great Quantity of the Phlogiſton ſhould be diſſipated by the Fire. The Mixture will melt, and Liver of Sulphur, all the Principles of which are preſent, will ſoon be produced: When this is diſſolved in Water, *Lac Sulphuris* may next be precipitated out of it, and this be ſublimed into perfect Flowers of Sulphur [*].

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[*] Sulphur may be produced of animal Urine, and *Stercus*, according to the moſt ingenious and ſkilful Chemiſt Mr. *Ambroſe Godfry* [*Hanckewitz*] F. R. S. in his Account of his Preparation of the Phoſphorus, wherein he has ſucceeded beyond all, who have attempted that moſt curious and ſurprizing, though dangerous Proceſs. See the *Philoſ. Tranſact.* N°. 428. p. 70.

OF ARSENICK.

PROCESS LXIX.

The Separation of Arſenick out of its Ore, by Sublimation.

APPARATUS.

1. DO every Thing as was ſaid about Sulphur and Mercury: But let the Veſſel which is put into the Fire with the Ore in it, be of Earth or of Stone, and the Recipient be of Glaſs, and of a middling Capacity: Nor is it neceſſary that this ſhould be filled with Water, ſo it be but well luted. The Fire muſt likewiſe be ſtronger, and continued longer, than for the extracting of Sulphur. Nevertheleſs, every Kind of Arſenick cannot be extracted in a confined Fire: For, it adheres to the *Matrix* more ſtrongly than Sulphur and Mercury. You will find in the Part of the Veſſel which is more remote from the Fire, pulverulent and ſubtile Flowers of Arſenick, but there will adhere to the poſterior Part of the Neck of the Retort, ſmall ſolid Maſſes, ſhining like ſmall Cryſtals, tranſparent, ſometimes gathered into a ſolid Sublimate, and perfectly white, if the Ore of the Arſenick was perfectly pure: Which nevertheleſs happens very ſeldom. The Flowers are moſt commonly thin, and of a grey Colour; which proceeds from the Phlogiſton mixt with the Maſs; they are often of a citron or a golden Colour; which is a Sign that there is in the Mixture ſome of that mineral Sulphur, which commonly proceeds from the white Pyrites, with which ſomething of the yellow ſulphureous Pyrites is almoſt always intermixt. But it will be a Sign of a conſiderable Mixture of Sulphur, if you ſee the red or yellow melted Sublimate, of which we have already ſpoken (*Proc.* LXVII). Wipe off the whole very clean; then collect and weigh it.

2. If you roaſt the Reſidue in a Crucible till ſmoaks no longer, or rather in an earthen flat Veſſel not glazed, and in a ſtrong Fire to be ſtirred now and then with a Poker, and then weigh it when grown cold, you will be able to know, how much Arſenick remained in it in the cloſe Veſſel; unleſs the Ore contained Biſmuth.

The Uſe and Reaſons of the Proceſs.

1. Arſenick is of itſelf more fixt than Sulphur, and is very ſtrictly united to ſeveral Metals, Earths, and Stones, not even excepting Glaſs itſelf, and vitreſcent Stones, and Salts: So that it remains with them, though melted in the moſt violent Fire, evaporating but little, and carrying Part of them away with it, when expelled by a violent Action of the Fire and Air: Which appears very plainly in the *Cadmia Fornacum*, or Tutty. The Glaſſes in which it is ſublimed, are alſo penetrated by its Vapour, ſo that they grow milk white throughout their whole Subſtance: Which evidences its penetrating through all Bodies. It melts with many of the *Matrix's* in which it lies hidden, when you ſuddenly apply to it a middling melting Fire: Thus in the white Pyrites, which can hardly be conquered by Fire alone, becauſe of the little Quantity of martial Earth and great Quantity of unmetallick Earth it contains, it turns to a Maſs in Appearance of a ſemi-metallick reguline Nature, but not ſo in reality: Becauſe a great Part of it is unmetallick, and difficult to be ſeparated from the Arſenick, unleſs you uſe a Fire increaſed by Degrees, which at laſt forces the Arſenick to abandon the fixt Part of it. The ſame happens with almoſt all Metals and Semi-Metals; nay, it adheres alſo to their Scoria's and Calx's, it melts with them, and cannot be ſeparated otherwiſe than by a ſlow Roaſting. Arſenick is well fixt in pure Earths, and brings them to a Fuſion without any Metal: For this Reaſon, when it is ſometimes in ſmall Quan-

tities in Spaads, Marles, *&c.* it exhales nothing in a gentle Fire, and in cloſe Veſſels: But in a ſtrong open Fire, it at laſt ſpreads an unpleaſant arſenical Smell, and diminiſhes the Weight of the whole concrete Body. Whence thoſe who try to make Parget with Spaad, get ſometimes Illneſſes, while they bake their Parget, and their Moulds to caſt Metal into: For this Reaſon likewiſe, Spaad and Parget made with it, which is done with a gentle Roaſting, ſometimes melts in a ſtrong Fire; whereas it could not otherwiſe be brought to it by a great Fire. The Efficacy of this Body is very great in promoting dry Solutions, and it is conſiderably increaſed, when it is joined with a Body fixt in the Fire, and fuſible; for Inſtance, with plain Glaſs of Lead, or with Glaſs made of Lead tainted with Arſenick, the Effect of which is much greater than common Litharge, or Glaſs of Lead. You may find out in cloſe Veſſels the Preſence of Arſenick lying in a ſmall Quantity in any Body whatever, by grinding it together with mineral Sulphur, and then ſubliming it, uſing a ſtrong Fire in the End of the Operation: If there is then ſome Arſenick, there will ariſe, towards the End of the Operation, ſome Flowers of an Orange-colour, and a half-tranſparent ruby-coloured Sublimate, in which the Arſenick lies hidden: For this is raiſed along with the volatile Sulphur; whereas it could not otherwiſe be eaſily detected by Sublimation. But in Orpiment, which, beſides the Arſenick, contains a Quantity of Sulphur not inconſiderable, the Earth which in this Mineral contains hardly any Metal, is melted together with them in a gentle Fire, and turns to a half-tranſparent red Maſs, out of which you may, by a gentle Sublimation, or by Means of a Deſpumation, ſeparate this Earth, which contains a great deal of Arſenick fixt in it, not to be diſſipated without a great open Fire, increaſed by Degrees, and continued long.

2. The Phlogiſton added, and the Fire applied in various Manners, give Arſenick a Variety of

outward Forms: Otherwiſe, Arſenick is but one and the ſame, ſo it be but pure. When perfectly pure, it is of a white Colour: When joined with a Phlogiſton, it becomes of a grey, blackiſh, aſh-colour: And this is true not only of ſublimed, but alſo of native Arſenick: As it is plain in the native black Arſenick, called in German **Schwartzen-fligenſtein**, out of which a grey Kind of Arſenick is produced by Sublimation. Arſenick ſublimed with mineral Sulphur, is always of an orange, yellow, or red Colour. But the Phlogiſton is eaſily detected in Arſenick both ſublimed and native, when you reduce this to Powder, and caſt it upon Nitre melted in a Crucible: For then you ſee a bright Flame and Detonation, which is produced by the leaſt Quantity of any Kind of Phlogiſton whatever, mixt with Nitre. They, indeed ſay, that Nitre detonates with Arſenick; that it produces a Flame, and that then the blue Spirit of Nitre of *Stahl* is expelled at the ſame Time: But pure, white, cryſtalline Arſenick, gives no Flame with Nitre; though it has the other Properties mentioned. You muſt make the Experiment about this Matter, with the following Precautions. Reduce a few Ounces of the pureſt Nitre into Powder, and put it into a deep wide Crucible: Put the Crucible into a wind-Furnace, and add gradually hot burning Coals that have ceaſed to crackle, leſt the Veſſel be ſplit: nor muſt theſe Coals be heaped up higher than half the Height of the Crucible, which, mean while, muſt be covered againſt the Fall of burning Coals into it: When the Nitre melts in ſuch a Degree of Fire as makes it grow moderately red, add at ſeveral Times Powder made with a ſolid Bit of white cryſtalline Arſenick: A noiſy Ebullition is immediately produced, ſo that ſometimes the foaming Nitre runs over a large Veſſel; a Fume is emitted which is arſenical at firſt, and afterwards perfectly of the ſmell of *Aqua Fortis*; which being received through a hollow Retort into a Glaſs Recipient applied to it, reſembles much the penetrating Spirit of Nitre. You muſt be cautious in this Proceſs, not to uſe ſmall Bits of Arſenick diſperſed in ſmall Chip-Boxes, or wrapped up in Paper. For the minuteſt animal or vegetable Fibre makes a pretty impetuous Deflagration with Nitre melted or burning: For which Reaſon alſo, you are to uſe the cleaneſt Tools; leſt any Phlogiſton ſhould get into it. Next, make the Operation under a Chimney, which carries Smoak very well; leſt a noxious Vapour ſhould annoy you. If the Mixture of Nitre and Arſenick is once put into Veſſels well luted, to diſtil the above-mentioned Spirit; by increaſing the Fire, the Mixture breaks the Veſſels aſunder with a Noiſe, juſt as if a Phlogiſton had been mixt with the Nitre, reſembling a true Deflagration, not without ſome Danger for the People that ſtand by.

3. The Conſiſtence of Arſenick varies, and chiefly depends upon the Fire applied to it. For Inſtance, if an arſenical Vapour finds a cold Place, it applies itſelf to ſolid Objects in Form of a Powder, as Sulphur does, which Powder is more ſubtile in Proportion as it is more remote from the Fire. Arſenick is collected under this Form in large Operations, which are made, while the arſenical Ore is thrown into the Furnace with the Fuel of the Fire, out of which Furnace the Smoak is laterally conveyed through a Funnel, into a large Channel made with wooden Boards. This Channel is ſeveral Fathoms long: Nor is the Direction of it ſtrait, but forming ſeveral Elbows, to the End that the Smoak may meet with more frequent Obſtacles, by which being retarded it may apply itſelf, while the reſt goes out at laſt, through a wooden Funnel conſtructed at the other Extremity of the Channel. This Powder is called in German **Gifft-mehl**, and it has a grey or aſh-Colour, cauſed by the Smoak of the Fire. But if it is ſublimed in a covered Veſſel, leſt it ſhould fly away too freely, the arſenical Flowers begin to grow clammy, in that Part of the Veſſel which is at laſt made hot by the long Continuation of the Fire, and gather into a ponderous thick Sublimate: Nevertheleſs,

theleſs, this Sublimate does neither run out, nor get to the Bottom of the Veſſel, when the Fire is increaſed: For a tenacious doughy Clamminеſs is indeed communicated to Arſenick by too violent a Fire; but Fire alone cannot make it melt, ſince it, on the contrary, reſolves it moſt quickly into a Smoak, which finding no Way to eſcape, breaks aſunder the Veſſels that keep it confined. The yellow Arſenick aſſumes more eaſily the ſolid Form of Sublimate, on Account of the tenth or twentieth Part of Sulphur mixt to it, by which Arſenick is brought to a State of Fuſion. But the red Arſenick, which is mixt with a ſtill greater Quantity of Sulphur, cannot even be conveniently prepared in a Sublimation by Aſcent, on Account of its too great Fuſibility, which is communicated to it by an Abundance of Sulphur: But it adheres either above in Form of Flowers; or runs quite melted to the Bottom of the Veſſel, leaving only a thin Cruſt of red tranſparent Sublimate, and ſome ſmall Drops. Therefore, in order to be able to prepare it quicker, and in larger Bits, it muſt be forced out of a Retort; in the warm, large, though not too long Neck of which it muſt be condenſed, and thence fall as yet fluid into the Recipient applied to the Retort, and grow cold. Arſenick of this Kind may be produced immediately out of Pyrites, without any Addition, if a ſulphureous Pyrite is intermixed with a white Arſenick one, or with ſome other Arſenick-Ore, or added to it for that Purpoſe. And thus you will have yellow or red Arſenick, according to the Quantity of the ſulphureous Pyrites.

3. In all Operations made with Arſenick, you are to take Care not to take in the leaſt Quantity of it, either in Subſtance or in Form of Fumes, nor even to touch it frequently with your Hands: For it is a moſt pernicious Poiſon; even when taken in a ſmall Doſe it is mortal with moſt dreadful Symptoms, and when now and then applied in a very ſmall Quantity, it produces Effects, which at laſt prove incurable: Whence a great many have loſt their Lives,

for having managed it without Caution. Therefore, let all Proceſſes with Arſenick be made under a Chimney that carries Smoak well : For the Vapour of Arſenick is not ſo quickly condenſed, but ſomething of it eſcapes through the Joints of the Veſſels, and fills the Air with a Poiſon, which betrays itſelf, by its unpleaſant garlick-like Smell. It is ſtill more dangerous, when to be reduced to a fine Powder: For notwithſtanding its great ſpecifick Weight, when the Powder is violently agitated; it is eaſily carried away by the Air, not affecting the Smell nor the Taſte, but yet pernicious, if drawn into the Lungs together with the Breath.

PROCESS LXX.

Mercury ſeparates mineral Sulphur from Arſenick.

APPARATUS.

1. LET the Arſenick be reduced to a moſt ſubtile Powder by a ſlow Trituration: Which is very conveniently performed in a ſtone-Mortar. This done, pour upon it a few Drops of Mercury: Continue the Trituration, the Mercury will inſenſibly diſappear, and the fine yellow or red Colour of the Arſenick will be darkened: This done, add ſome more Mercury without ceaſing the Trituration; till at laſt the Powder receives no more Mercury, and there remains not the leaſt Appearance of the yellow or the red Colour in the Mixture, but it aſſumes either a grey Colour, if there was but very little Sulphur in the Arſenick, or a black Dye, if it contained a good deal: Which can hardly be done in ſome Hours, if you employ a Pound of Arſenick. But in this very Caſe, it is proper to perform the Trituration in ſeparate Parcels.

2. Fill about one third, or one half Part of the Belly, of a high, narrow glaſs Cucurbite, not cut off: Apply to this, inſtead of an Alembick, another large inverted Cucurbite, cut off at Top, and ſtop the Joints with Lute: Put it into a Sand-bath, in a Situation ſomewhat oblique: Nor muſt you gather your Sand around it, higher than the Mixture in the Cucurbite: Then perform the Sublimation, in a Fire ſomewhat gentler than Cinnabar requires: The arſenical white Flowers will adhere above, together with neat white Cryſtals of Arſenick, or they will be grey, and the ſublimed Cinnabar will be lower, nor will this, however, be altogether void of Arſenick.

The Uſe and Reaſons of the Proceſs.

1. A great Quantity of Sulphur melted with Arſenick, may be ſeparated from it for the greateſt Part, by a gentle Sublimation (*Proc.* LXIX): But a Part of the Sulphur is ſo ſtrictly detained by the Arſenick, that they can never aſcend but both together; in ſuch Manner however, that the firſt Sublimate and the Flowers are richer of Sulphur, while that which aſcends laſt, contains little or no Sulphur at all: But this requires a gentle Fire ſlowly increaſed.

2. A more perfect Separation of Sulphur and Arſenick is obtained by Means of Mercury, and even at firſt the Sulphur is joined to the Mercury the cold way, by Trituration alone: Which we learn from the Production of the *Æthiops Mineral*, which being afterwards ſublimed by Fire, turns to Cinnabar. But this Experiment will never ſucceed to your Satiſfaction, unleſs the Trituration of the Arſenick with the Mercury is very well performed: For elſe, when the Fire begins to act, there aſcend firſt of all Flowers of an Orange-colour, on Account of the mineral Sulphur, which Flowers are more volatile than the pure Arſenick that follows and fill the upper-Part of the Veſſels, ſpoiling the ſaid Arſenick; becauſe

the Sulphur was not yet united with the Mercury: Therefore, you muſt add rather more than leſs Mercury, that all the Sulphur may be detained. Next let the Fire not be too violent nor too precipitately applied, becauſe it confounds all the Ingredients together: Nor muſt the Necks of the Veſſels be too large. However, as Arſenick is employed pure for other Uſes, this Separation is never made; becauſe it requires a great Labour, and yet is never completely performed. For a great Quantity of Arſenick, ſeparated from the Sulphur, adheres to the white, ſhining, ſolid, diſtinct, ſmall Maſſes, which are between the Sublimate of the Cinnabar, and the ſmall Drops of the Mercury that have not been diſſolved by the Sulphur. Whence, the Cinnabar appears rather of a grey than a red red Colour, and may at laſt be totally ſeparated, by repeating and well performing the Sublimation.

3. The Foundation of this Proceſs is then, that Mercury is diſſolvable by Sulphur, and on the contrary rejects Arſenick. Therefore, as the other Metals and Semi-metals have an equal Affection for Arſenick and Sulphur, or reject them both, the Separation of the latter by the former will not ſucceed; or if any Kind of it is obtained, it happens in an inverted Proportion; for Inſtance, when the Sulphur aſcends eaſily, the Arſenick is detained in the *Caput Mortuum*, which is diſſipated by a ſtrong and commonly an open Fire: If any is obtained, it is generally not true, and impregnated with Phlogiſton. See *Henckel. Pyrit.* p. 558.

PRO-

PROCESS LXXI.

The purifying of Arſenick by Sublimation with a fixt Alkali, to make it white and cryſtalline.

APPARATUS.

IF inſtead of Mercury (*Proc.* LXX.) you uſe a fixt Alkali well burnt, ſuch as Pot-aſh; there comes forth a half-tranſparent, white, ſolid, hard, ponderous Sublimate of Arſenick, which adheres below, and pulverulent white Flowers join to it above. But the Fire, muſt be much more violent in this Sublimation than in the foregoing, eſpecially towards the End: Wherefore you muſt alſo chuſe higher Veſſels, that the arſenical Vapours may find a Space leſs warm to which they can apply themſelves. You are alſo to take Care, not to add more Alkali than is neceſſary to retain the Phlogiſton: Which cannot be exactly determined: For you will obtain Arſenick with greater Difficulty, and in leſſer Quantity, as you uſe a greater Quantity of Salt, and on the contrary.

The Separation of the Phlogiſton will ſucceed with a ſmall Quantity of Arſenick, if you firſt ſprinkle the Arſenick reduced to a very fine Powder, with a very pure alkaline Solution, and then dry it ſlightly before the Sublimation. Likewiſe more Arſenick is produced by this Method in a gentle Fire.

The Uſe and Reaſons of the Proceſs.

1. Fixt Alkali well burnt in an open Fire is very greedy of a Phlogiſton, if you except Acids and Water on certain Conditions, and when it has abſorbed it, it does not entirely quit it again eaſily, unleſs you hinder the too free Action of the Air; let the Violence of your Fire be ever ſo great: Which

may be experienced in the Diſtillations of Tartar and of common Soap, and in the Operation made with reducing Fluxes; wherein there remains always ſomething of the Charcoal. Arſenick, with the leaſt Quantity of Phlogiſton, aſſumes a grey, aſh, and black Colour, or the orange or red Colour, when Acid of Vitriol is added to the Phlogiſton. When the Phlogiſton is expelled, it appears again under its white Colour. When white, it is again defiled with the ſaid Colours, by a ſmall Addition of Phlogiſton, if it is firſt digeſted with it, and ſublimed again, as the above quoted Author ſays, with Oil of Almonds. Vid. *Pyritolog.* p. 558.

2. But the Phlogiſton is not only detained by a fixt Alkali; but a great Part of the Arſenick itſelf is alſo fixt by it to ſuch a Degree, that it cannot be intirely diſſipated out of it by any Fire, not even an open one; and even turns to Glaſs with it by adding ſome Flints: Therefore, fixt Alkali muſt not be added too liberally. Thence it is plain, that this Separation of Arſenick and Sulphur does not take Place, if the latter is mixt in too great a Quantity with the former; and that you muſt have Recourſe to other Remedies. See *Proc.* LXX. and LXIX. But a ſmaller Quantity of Salt is ſufficient to ſeparate the ſame Mixture of Arſenick and Phlogiſton, in Proportion, as all the Ingredients are more intimately mixt together: Which is better obtained by a Sprinkling with an alkaline Solution, than by a dry Trituration: Becauſe all the ſmall Maſſes of Arſenick are ſurrounded and penetrated with the Salt in the former.

3. It is wonderful, that this Separation of the Phlogiſton and Arſenick can hardly be completely performed by any Body, beſides fixt Alkali, unleſs by Mercury (ſee the above-cited Place); although there are much more potent Magnets of inflammable Matters, than Mercury is. The Thing cannot be done at all with Metals; nay, the pureſt white cryſtalline Arſenick, ſublimed upon Metals that are gra-

nulated,

nulated, or filed very fine, (pure Gold and Silver excepted) aſcends rather the ſooner, and is ſullied with a brown Colour, of which it muſt be again purified by the foregoing Method.

4. As the remaining alkaline Salt is ſtill impregnated with no ſmall Quantity of Arſenick; it is very good to make white Copper, and to impregnate the other Metals with Arſenick: For which Purpoſe, ſome [illegible]pare fixt Nitre by a Detonation with Arſenick (ſee Proc. LXIX. Uſe No. 2.) in which Nitre a great [illegible]ntity [illegible] A[illegible]k is fixt, which being afterwards [illegible] with C[illegible]r, gives it a white Colour *. By which Means a [illegible]onſiderable Malleability is preſerved in the Copper.

PROCESS LXXII.

Arſenick is reduced into a ſemi-metallick Form, with a Phlogiſton.

APPARATUS.

1. GRIND together two Parts of white, cryſtalline Arſenick finely pulveriſed, or of the Flowers of it, with one Part of the black Flux, one half Part of Sandiver, and as much of Filings of Iron not ruſty, that they may mix well together. Fill with this Mixture a ſtrong wide Crucible, and cover it with common Salt one Finger's breadth high: Then, cover it with a Tile, or an inverted Crucible having a ſmall Hole in the Middle. Put it in the Wind-Furnace. Make firſt a gentle Fire, that the Veſſels may warm equally. When the Arſenick begins to ſmoak, increaſe the Fire ſuddenly, that it

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* This is the white Prince's Metal, invented by Prince *Rupert*, of which Buckels, Spoons, and many other Utenſils are made, to imitate Silver; but they ſoon tarniſh; to mend which they cover over this Metal with a thin Coat of Silver, and poliſh it, which is ſold by the Name of *French* Plate.

may be of a moderate melting Degree, and put the Mixture in Fuſion: This done (which may be found out with an Iron-wire introduced through the ſmall Hole bored in the upper-Crucible) take the Veſſels out of the Fire, put them into a cold Place, and, when cooled, break them: You will find a *Regulus*, which will be more ſoft, more brittle, and of a darker Colour, in Proportion as it doth contain more Arſenick, and leſs Iron. On the contrary, if a great deal of the Arſenick has been diſſipated, becauſe of the too ſlow Application of the Fire, it will then be harder, more ſolid, and whiter. It may alſo be poured into the melting Cone, when the Mixture is in greater Quantity: And being thus ſooner cooled, ſo great a Quantity of the Arſenick is not diſſipated.

2. *Regulus* of Arſenick may be prepared with Copper after the ſame Manner; which, retaining likewiſe a great Quantity of Arſenick, will, on this Account, be very brittle, and of a dark Colour; but, when the Arſenick is in great Part diſſipated, it will be neater and harder, ſometimes as brilliant as Silver, half-ductile, with a very ſlight yellow Caſt. This is a kind of whitened Copper.

3. Arſenick intimately mixt with Flux, warmed firſt ſlowly, and at laſt melted ſuddenly, though not with too great a Fire, is collected into a *Regulus* of a ſemi-metallick Kind, but ſoft, light, and pretty bright, though not of a laſting Colour: Nay, the fine Brightneſs it has at firſt when broken, vaniſhes in a few Days and turns black, though not throughout the Maſs, but only at the Surface. This *Regulus* being brought near a Candle, without any Addition of Arſenick, ſeems to nouriſh the Flame, like the red Arſenick charged with Sulphur, and vaniſhes at the ſame Time into a pernicious Smoak, in which it may be thus totally reſolved: This Smoak gathered under the Form of Flowers, is the grey Arſenick (*Proc.* LXXI. and LXX.) Theſe Proceſſes muſt be performed under a Chimney that carries the Smoak

well, leſt the poiſonous Fumes, coming forth with great Violence, ſhould prove hurtful to the Artificer.

The Uſe and Reaſons of the Proceſs.

1. Copper and Iron render the Precipitation of the *Regulus* of Arſenick abundant and eaſy in this Proceſs, but they do it from another Cauſe than in the Production of the *Regulus* of Antimony. For in the latter they were added, that the mineral Sulphur, which retained the reguline Part diſſolved in crude Antimony, might be abſorbed by them; which done, the *Regulus* rendered free went to the Bottom, while the Metal that was in the Mixture charged with Sulphur, ſwam at Top in Form of Scoria's. But, in this Operation, Arſenick, which is of itſelf altogether volatile, muſt be expoſed to a very violent Fire ſuddenly applied, that it may be fixt with theſe Metals, after having been reduced to a ſemi-metallick and very volatile *Regulus*. Whence it is likewiſe ſelf-evident, that the *Regulus* of it participates very much of any precipitating Metal whatever, and is leſs uncompounded than the *Regulus* of Antimony precipitated by Metals, and that of Courſe it cannot be purified again by way of Fuſion: For it is preſently reſolved into Fumes, as ſoon as it is ſeparated from the Metal that fixes it.

2. If this *Regulus*, precipitated with Copper or Iron, is beaten to a coarſe Powder, and then a great Quantity of it is ſublimed, the ſemi-metallick arſenical Part is for the greateſt Part carried up, and muſt be looked upon as the pureſt reguline Subſtance of Arſenick: For there remains at the Bottom of the Cucurbite, that Metal by which the *Regulus* has been precipitated; but it is tainted with a great Deal of Arſenick: Nor can it be diſſipated otherwiſe than by repeating the Roaſting and the Pulveriſing, in an open Fire increaſed by Degrees. See particularly the Proceſſes about *Iron* and *Copper*.

3. The *Regulus* of Arſenick is very difficultly got without any Addition. For every reducing Flux is very refractory, with regard to the great Volatility of this *Regulus*, ſo that it is moſt quickly diſſipated by the ſame Fire that melts it, and then either diſappears intirely, or adheres diſperſed among the Scoria's, to ſmall ſhining ſpungy Maſſes: Which happens alſo, when there is not the Degree of Fire neceſſary for the Fuſion of the Flux. There is alſo a great deal of the Arſenick that remains in the Scoria's totally diſſolved, and not apparent at all. For this Reaſon, there muſt be much more Arſenick than Flux, and they muſt be mixt together by Trituration; the ſtricter, the better. Arſenick may be produced under a ſemi-metallick Form, out of the ſame Mixture of Flux and Arſenick, by a ſtrong Sublimation: This may be done very conveniently with a ſmall Earthen Cucurbite, to which another of Glaſs muſt be applied: This muſt by all Means be horizontally ſituated in a Furnace fit to make Diſtillations in an open Fire, which being ſtrongly increaſed, the Arſenick aſcends, and applies itſelf to the colder Region of the Veſſels, partly in blackiſh thin-ſet Flowers, partly in a Sublimate compoſed of a Collection of ſmall ſcaly ſhining Maſſes.

4. Let Arſenick be reduced to a ſemi-metallick Form, by whatever Method you will, according to the foregoing Directions, it will re-aſſume its white cryſtalline Form, by a Sublimation with fixt Alkali, or Mercury (*Proc.* LXXI.)

OF VITRIOL.

PROCESS LXXIII.

To extract Vitriol out of the Ink-ſtones (Part I. § 421.) *and to cryſtallize it.*

APPARATUS.

1. AN aſtringent, ro[illegible]h, ſweetiſh, ſtyptick, nauſeous Taſte [illegible]ys the Preſence of ſome Vitriol, or Allum, in a [illegible] terreſtrial Concrete. Now, if you want to be cer[illegible]in, what this Concrete is, and how much it conc[illegible]s of the ſaid Minerals, beat the Clod of Ore to [illegible]vder, and boil it in a Glaſs-Cucurbite cut off at [illegible]p, or in a Veſſel made of milled Lead, with thre[illegible] Times the Quantity of pure Water. Stir up the turbid Water ſtill warm with a wooden Stick, pour it into a double filtrating Paper, previouſly moiſtened with Water, and placed in a Glaſs Funnel: This muſt be done, leſt a great Quantity of the Water which contains Vitriol, eſcaping at the upper Part of the filtrating Paper, ſhould diminiſh the Product conſiderably, eſpecially if you uſe but a little of the Ink-ſtone. Let the pulverized Clod of Ore be boiled a ſecond Time with a double Quantity of Water, and repeat this ſo long as the Taſte of the Vitriol is ſtrongly perceived in the boiled Water: Then filtrate theſe Solutions, and pour them upon the firſt Solution.

2. When all the Solutions are collected in a Glaſs Cucurbite, cut with a wide Opening, put them in a Sand-bath, and make a Fire ſo ſtrong as that a thick Vapour may come out, but the Fluid not boil: Continue this Degree of Fire equally, and without Intermiſſion: So ſoon as you ſee thin Pellicles on the Surface of the Solution, like Duſt that might have

fallen upon it, ſwimming at Top, let the Veſſels grow cold, and put them in a cold ſtill Place for one Day and one Night, that Cryſtals may gather, which muſt be collected by decanting the remaining Liquor of the Solution. Dilute the Reſidue with the double Quantity of Water, filtrate and inſpiſſate it, and ſet by for Cryſtallization, as before; till what remains at laſt refuſes to turn any more to Cryſtals, but aſſumes an oily Conſiſtence. Conſider every Time ſeparately the Cryſtals produced, to ſee whether they have the Properties of Vitriol (Part I. § 417). But in each Cryſtallization, an Oker of a yellow Colour will be produced, which is expelled in a greater Quantity, as the Inſpiſſation is performed more ſlowly and inequally, or even when the Solution is kept too long at reſt, though it be perfectly tranſparent.

The Uſe and Reaſons of the Proceſs.

1. There are many Ink ſtones that conceal different Kinds of Vitriol confounded together (*Part* I. § 417.) and ſometimes Allum into the Bargain. The latter is very eaſily diſtinguiſhed, when the Inſpiſſation and the Cryſtallization are diſcretely performed: By which Method ſome Salts may be ſeparated from each other, which being confounded with an Inſpiſſation too haſtily made, cannot be well diſtinguiſhed. The Difference which, is between theſe Vitriols, proceeds from a Variety of the Proportion, in which the green Vitriol of Iron [*] and the blue Vitriol of Copper [†] are joined to each other. Allum itſelf mixes with them pretty often, which appears clearly, if you diſtil Oil from Vitriol, or calcine this ſtrongly, and edulcorate with Water the *Caput Mortuum* which is very red. This Water being inſpiſſated and cryſtallized, produces whitiſh Cryſtals, which are called *Gilla Paracelſi* [‖], and have concentrated in them the Allum

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[*] In the Shops called Copperas.

[†] Known by the Name of *Roman Vitriol*, or the blue Stone.

[‖] Salt of Vitriol.

which was in the Vitriol. Nay, this *Gilla* is more impregnated with Copper, than the Vitriol out of the *Caput Mortuum* of which, it has been made. For Allum moſt difficultly loſes its Acid in the Fire: Therefore, if you pour Water upon it, after a ſtrong Calcination, it may be reduced almoſt totally to Cryſtals again. Likewiſe, Copper is not ſo eaſily deprived of all its Acid by Fire, as Iron is, though the former be precipitated by the latter.

2. The Vitriols of Iron [*] and of Copper may eaſily be produced by Art, and even that of Iron by ſimply pouring upon it Oil of Vitriol, diluted with ſix or eight Times as much Water, when it is too much concentrated (*Part* I. § 109.) But the Solution muſt be left for one or two Days in a moderate Heat, and more Iron be added than the Oil of Vitriol can diſſolve. Then, when the Solution is thoroughly ſeparated, filtrate it, evaporate it, and reduce it to Cryſtals as before, and you will have green Cryſtals: This Solution alſo lets fall a great Quantity of yellow Oker during every Inſpiſſation; and even when you let it reſt for one or two Days, it grows opaque, and aſſumes a ruſty Colour. But, if you let fall into it a few ſmall Drops of Oil of Vitriol, to make it very ſlightly acid, it remains long limpid, and if it is inſpiſſated and put at reſt for a Cryſtallization, this yellow martial Earth doth not ſubſide: The Cryſtals which are then produced, become leſs yellow, of a Graſs-colour, and keep their Whiteneſs and Tranſparency longer, but are a little more acid. Thence it is plain, how vain is the Labour of thoſe who try to purify the Vitriol of Iron, by theſe repeated Solutions, Inſpiſſations, and Cryſtallizations. For it is totally reſolved into theſe Okery Dregs, and if it contains any Copper, there remains at laſt almoſt mere Vitriol of Copper.

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[*] Vitriol of Iron is called *Copperas*, and is made in great Quantities at *Deptford*, near *London*, of ruſty Iron, old Nails, &c. and Pyrites.

3. If you throw a little Filings of Iron into [a Solution of] Vitriol made with Ink-ſtones or Pyrites, the Copper, if it contains any, is precipitated to the Bottom; ſo that with regard to it, it is as pure as the factitious Vitriol of Iron (N°. 2.)

4. Vitriol of Copper is prepared in an inſtant with Oil of Vitriol as (N°. 2.): But, this is not ſo much ſaturated with Metal: For Copper does not ſo readily yield to Oil of Vitriol, as Iron does. The Operation ſucceeds better, if you ſtratify Plates of Copper with Sulphur in an Earthen-Veſſel, ſhut cloſe with a Tile and with Lute, and then put the Veſſel into the Fire, till it is middling red-hot. Thus the Plates are corroded by the Sulphur, and become of a dark Colour, and much thicker than they were before: This is called burnt Copper. The Copper, being penetrated by the Sulphur, is afterwards roaſted in a moderate open Fire, till you no longer ſee any ſulphureous Flame: Thus by pouring Water upon it you may get a very fine azure-coloured Solution of Vitriol of Copper, which muſt be reduced to Cryſtals.

PROCESS LXXIV.

The making of Vitriol out of the Ores of Iron and Copper.

APPARATUS.

1. A Very great Quantity of common Vitriol, ſuch as is ſold in the Shops, is got out of Pyrites: Some of them having very little or no Copper in them, when expoſed to the Air, turn of themſelves to Ink-ſtones. Theſe are merely charged with Sulphur, and very little arſenical. However, they do not all ſo eaſily turn to Vitriol: And ſome of them will not do it at all. They muſt be beaten to a coarſe Powder, and thus expoſed to a pretty moiſt Air,

till

till their outward pyritoſe Brightneſs and Hardneſs do totally diſappear, and even the inward when they are beaten afreſh. Do the reſt as in *Proc.* LXXIII.

2. The other Pyrites, among which ſome are coppery, and impregnated with a great Quantity of Arſenick, and many purely ferreous and ſulphureous, require a previous Roaſting. This is performed either in cloſe Veſſels (by which Operation the Sulphur is collected together (*Proc.* LXVII); or in a moderate open Fire. The Vitriol is not yet generated in ſome of them; but they muſt be firſt expoſed to an open ſomewhat-moiſt Air, as N°. 1; or if the Air is too dry, you promote the Production of the Vitriol, by now and then ſprinkling them very ſlightly with Water. Then the Vitriol is produced ſooner or later in the ſeveral Pyrites. But ſome afford Vitriol immediately after the Roaſting, though in a much ſmaller Quantity, than when they are afterwards expoſed to the Air in the Manner abovementioned. Then waſh the Vitriol clean. If you expoſe again to an open moiſt Air what remains of the Edulcoration, which is called the *Caput Mortuum*, it is commonly ſtill impregnated with Vitriol, but in a much leſſer Quantity.

3. There are many Stones of Calamine, which yield a no inconſiderable Quantity of Vitriol, immediately after the Roaſting: Nor is it neceſſary to expoſe them any more to the Air.

The Uſe and Reaſons of the Proceſs.

1. We ought here to give the Reaſon, why ſome Pyrites turn of themſelves very eaſily to Vitriol, when only expoſed to a free Air, ſome with greater Difficulty, and a great many not at all, even in the Space of many Years together: And again, why ſome Pyrites preſently yield as much Vitriol as can be got out of them, when waſhed in warm Water, while ſome muſt at ſeveral Spaces of Time be again expoſed to a moiſt Air after the Roaſting; tho

this Matter has not been examined ſo cloſely, but there remain ſtill many Doubts about it. I ſhall here in a few Words mention the Diſcoveries Dr. *Henckel*, the Author ſo often quoted, has made by a Multitude of Experiments, and communicated to us in his Pyritology.

Viz. No Pyrites, containing any Copper or Arſenick, turn of themſelves to Vitriol, but they require a previous Roaſting.

The ſulphureous Iron-Pyrites, void of Copper and Arſenick, turn to Vitriol by the Action of the Air, and of the Things it contains, and this the quicker, as they are leſs compact: Such are chiefly thoſe which ſeem to conſiſt of a Multitude of Fibres and *Radii* gathered together. But there are a good many Exceptions to this: For there are Pyrites of ſuch a Kind, that they perſiſt unchanged for whole Years together.

Therefore we ſee Copper and Arſenick reſiſt this Alteration of the Pyrites, and it likewiſe follows, that there is another ſecret Cauſe hitherto unknown of this Conſtancy of the Pyrites, becauſe the Pyrites which are merely ferreous and ſulphureous, do not at all turn to Vitriol of their own Accord. I have expoſed ſuch Pyrites, moderately pulverized and not very hard, to the Injuries of the Air for whole Years together, but they perſiſt unchangeable to this very Day.

2. It is ſtill leſs known, why Vitriol is found in ſome Pyrites, if you but pour Water upon them after the Roaſting, while you find none in ſome others, unleſs you have expoſed them previouſly to the Air, at different Times. It even ſeems that we are to look in the Air for the Reaſon of this, as it carries moiſt Vapours with it. And indeed the Acid of Sulphur has not the Virtue to reſolve Iron into the Form of Salt, without a ſufficient Quantity of Water: Nay, Oil of Vitriol or of Sulphur itſelf, being moderately concentrated (though diluted with much more Water, than it is when united ſtill with Sulphur)

phur) does not even diſſolve Filings of Iron, unleſs you pour four or ſix Times as much Water upon them. But, the Thing being well conſidered, it is certain, that there is ſtill ſome other hidden Cauſe of this; becauſe it is not conceivable, why Water, poured upon ſome Pyrites, does immediately extract Vitriol out of them, and none out of ſome others; and again, why ſome crude Pyrites turn preſently to Vitriol in a free open Air, and never when immerſed under Water. I have met with ſuch ſulphureous and ferreous Pyrites on the Shore of the Northern Sea, that ſhewed no Sign whatever of Arſenick and Copper, neither before nor after their being changed to Vitriol. They were compoſed of parallel Fibres almoſt like Wood, very ſoft, and of a fine Brightneſs: But they were covered with a coarſe Sand ſome Feet deep, which the Water of the Sea could penetrate eaſily enough, and they had no Manner of Taſte, and conſequently were altogether void of Vitriol. But after they had been expoſed to the Air for a Fortnight, they loſt intirely their Brightneſs, and were become ſo rich of Vitriol, that ſmall green Cryſtals of the Size of Millet-ſeeds appeared on their Surface. Now if the Moiſture alone was ſufficient to produce this Effect, there is no Reaſon, why they ſhould not have been reſolved into Vitriol under a very moiſt Sand. There remains ſtill a wandering foſſile Acid, which fills alſo the aerial Region. Many affirm, indeed, that this concurs to promote an abundant Production of Vitriol, nor muſt we by any Means exclude it entirely, no more than the Moiſture of the Air. But whoever ſeriouſly conſiders what has been ſaid before concerning this, will own that there are ſome Conditions requiſite for the Production of Vitriol, which we do not as yet clearly underſtand.

3. We might here add ſomething concerning white Vitriol, and the other Species of factitious Vitriols; but we ſhall treat of theſe more at large on another Occaſion.

OF ALLUM.

PROCESS LXXV.

Preparation of Allum.

APPARATUS.

1. THE Minerals of Allum, as well as thoſe of Vitriol, muſt be prepared many different Ways, to get Allum out of them. For there are ſome alluminous, fat, bituminous Minerals, which, being heaped up in the Air, grow warm, ſmoak, crumble, and ſometimes take Flame; but this is not done without ſome Loſs of the Allum, and it muſt be prevented, by pouring Water upon and disjoining the concrete Heap: They finally ſeparate, and aſſume the ſweetiſh, ſtyptick, nauſeous Taſte of Allum, which before was but little or even not perceived at all in this Mineral. Some barren Minerals, as well as the Pyrites, require a gentle previous Roaſting, which being done, the Allum is at laſt produced. Chuſe out of this Heap a Specimen of ſome common Pounds, put it in a Lead or Glaſs-veſſel, and pour upon it three Times as much Water: Make it boil, and ſtrain it through a Filtre; pour again warm Water upon it, and make it boil another Time, that the remaining Earth may be well edulcorated. Pour the Solutions together, and let them reſt for one Day and one Night together, that the Dregs may ſubſide to the Bottom; or ſtrain it again through the Filtre: Then let the clear Liquor be ſo inſpiſſated as that it may ſuſtain a new laid Egg put into it: Let it grow cold again, and reſt four and twenty Hours: At laſt you will ſee what will be precipitated: For Cryſtals of Vitriol are ſometimes produced; and ſometimes the Allum is expelled. If

it is Vitriol, you muſt throw it away: But the Allum muſt be purified by a repeated Solution and Cryſtalization, which will be of a reddiſh bay Colour. Continue the ſame with what remains of the Solution, till it is intirely exhauſted of Allum.

2. But if no Allum is precipitated, the Solution muſt again boil on the Fire, then pour into it about one twentieth Part of ſaturated Lye of Pot-aſh, or one third Part of purified Urine, or alſo ſome Quick-lime: Mean while, continue to boil it: If there is any Allum, a white Precipitate will begin to be expelled, when the greateſt Part of the Solution is conſumed: Then let it cool and reſt, and decant the Solution from what is precipitated, and out of this remaining Solution the reſt of the Allum will be precipitated in the Manner already mentioned, till there remains at laſt a thick Liquor void of Allum. This done, diſſolve again, in a ſufficient Quantity of boiling Water, all that has been precipitated, purify it by letting it reſt, or by Filtration, and reducing to Cryſtals according to *Proc.* LXXIV.

The Uſe and Reaſons of the Proceſs.

1. Allum, precipitated by itſelf, conſiſts of a mere Earth, reduced into a Form of Salt by a vague foſſile Acid. But this Earth is of a moſt ſingular Nature, and different from the other native Earths that are known. For, with Chalk, Lime, and Spaad, diſſolved in this Acid, you will produce Salts ſomewhat like Allum, though never perfectly reſembling it. But, if this Earth is of that Kind, the Allum is white, or of a light reddiſh Colour: And when a Metal mixes to it in the Form of Vitriol, it is tinged with a bluiſh greeniſh Colour: And the Allum in this Caſe muſt be looked upon as impure. But, if the Precipitation of Allum is performed by a Solution of a fixt Alkali, or of volatile putrid Urine, then, indeed, as well as in all Precipitations, a great Deal of the precipitating alkaline Salt joins to the Allum: Which

ſeems to be the Reaſon why Allum is ſo laſting, ſuch as are the Cryſtals compoſed of Alkali, and of the vague foſſile Acid united together, and will not eaſily abandon its Acid in the Fire. For when it is made middling red-hot in the Fire, there comes out a very little Quantity of Acid; and if it is afterwards tormented by the greateſt and longeſt Fire, you can never extort any more of it; ſo that on this Account, the *Caput Mortuum* is moſt commonly looked upon as mere Earth, which nevertheleſs is in the greateſt Part diſſolvible by pouring hot Water upon it, and may be almoſt totally reduced again to its Form of Allum, by a reiterated Evaporation and Cryſtalization. But the Alkali is poured upon it not only becauſe of the Precipitation of the Allum itſelf, but alſo becauſe of the Separation of the Vitriol, which otherwiſe would be difficultly performed. You are to take Care at the ſame Time, not to add too much Alkali; therefore, it muſt be poured in by ſmall Quantities, to be repeated ſeveral Times, till you are ſure of a juſt Proportion. For the ſame Purpoſe, an Addition of Lime is not uſeleſs, and even muſt ſometimes be ſubſtituted, for a greater Security. As for the reſt, you muſt here make the ſame Obſervations as were made about Vitriol (*Proc.* LXXIV). The remaining Earths and Dregs, being expoſed anew to the Air, are again impregnated with Allum, but not all of them.

Theſe Proceſſes about Allum, as well as thoſe about Vitriol, do not always agree ſo exactly with thoſe which are performed in greater Quantities, for a greater Proportion is commonly produced in larger Operations. For ſeveral Artifices muſt be uſed in every Caſe, which muſt be underſtood from the peculiar Nature of each Mineral, by repeated Experiments: Whence you muſt generally repeat a few Times theſe Examinations, before you are able to paſs any certain Judgment.

OF NITRE.

PROCESS LXXVI.

The Preparation of Nitre.

APPARATUS.

1. WE have ſpoken of the Generation of Nitre, or Salt-petre (*Part* I. § 437, *&c*); there remains that we ſhould treat of the docimaſtical Extraction and Purifying of it. The Preparers of Nitre, commonly throw a few Pounds of the Earth, in which they ſuſpect there is any, into a wooden Veſſel with double the Quantity of warm Water, and ſtir it ſeveral Times with a Stick: Then they put two ſmall Copper-Diſhes of equal Weight into one of the Scales of Balance that is pretty true, and a docimaſtical Centner into the other Scale: They put ſome of the Solution drop by drop into the former, till an Equilibrium is obtained. They put the Scale which contains the Solution upon the Aſhes, or upon Sand that is middling warm, to make it thoroughly dry, and weigh it again, to know how much there remains of the Centner of the Solution of Salt. Then they take the Salt out of the Scale, and taſte it, to ſee whether it is nitrous; and put burning Coals upon it, to try whether it will deflagrate; which ſhews you that the Nitre is pure, if there remains little or no Alkali at all; but if it decrepitates and flies aſunder, you may judge that it contains a great deal of Salt, and then the Nitre proves the worſe.

Another Method.

1. YOU will find the Nature of it more exactly by the following Method. Take many common Pounds, for inſtance twenty or thirty, of ni-

trous Earth, and mix them with once and a half as much of quick-Lime and alkaline Aſhes, or add, inſtead of theſe, half a Pound of Pot-aſh: Put theſe Things into a wooden Tub of a ſufficient Capacity; pour upon them about the double Quantity of warm Water, and leave them thus for four and twenty Hours: It is proper to ſtir the Whole now and then with a wooden-Stick. Next, pour the whole Maſs into a linnen-Bag: The Lye will firſt paſs through turbid; pour it again into the Bag, to ſtrain it a ſecond Time; which done, it will be tranſparent and yellow. This done, let it boil in a large Kettle, till ſo much of the Liquor be diſſipated, as that a ſmall Drop of it let fall upon a cold Surface may congeal. Take the Kettle from the Fire, and let the Solution cool for one Day and one Night: You will ſee whether any Cryſtals (*Part* I. § 21.) are produced. Dilute the remaining Solution in the double Quantity of warm Water: Then inſpiſſate it, and let it cool; Repeat the ſame as long as Cryſtals will be produced by the Solution: There will remain at laſt a thick fat Liquid, which may indeed be inſpiſſated, but will not turn to Cryſtals, and eaſily runs to Water again in the Air.

3. If you are willing to have theſe Cryſtals very pure, diſſolve them in eight Times as much Water; filtrate them through a Paper; add to them a few Drachms of Quick-lime, and make them digeſt with it a whole Day. Drop into this Liquor a few ſmall Drops of an alkaline Solution. If, a little after you ſee ſmall Clouds in the Solution, go on, till it is no longer turbid: It is never neceſſary to drop above half an Ounce into it. This done, filtrate it through a Paper; evaporate it in a ſhort Glaſs-Cucurbite, and when you ſee a ſmall Pellicle, let it grow cold. The ſlower it cools, the larger and finer the Cryſtals will be. You muſt always dilute the Reſidue with the double Quantity of warm Water, before you expoſe it to the Evaporation, and repeat the Cryſtallization, till the Nitre is entirely exhauſted.

The Uſe and Reaſons of the Proceſs.

1. Nitre is produced out of ſoft Earths* impregnated with fat and ſaline Particles of vegetable and animal Bodies apt to come to a Putrefaction. But Nitre is never found perfect in them, unleſs fixt Alkali, or a limy Earth be joined to them. It is then proper to add alkaline Salts to the Earths in which Nitre is to be generated, or at leaſt to mix alkaline Aſhes or Lime to them, while the nitrous Earth is boiling for a Lye. For, it is certain from unqueſtionable Experiments, that theſe Things enter really into the Compoſition of Nitre. This is plain, from the abundant Quantity of Alkali that comes from Nitre, by Means of a very ſmall Quantity of Coals of Vegetables, having no fixt Alkali in them, ſuch as proceed from Muſtard ſeed, and the like: For if ſuch Coals being put upon melted Nitre, detonate with it by increaſing the Fire to a high Degree, and the Maſs is brought to a Fuſion like Water after the Detonation is compleated, you will have above one Half of fixt alkaline Salt, with regard to the Nitre employed; unleſs you have flung much of it out of the Veſſels, on Account of their ſmallneſs, or by putting imprudently too much Charcoal at once. This Alkali is called *fixt Nitre*, and is a little leſs Fuſible than any other pure fixt Alkali, becauſe of the ſubtil calcareous Earth which is in it. Nor does there then remain any Veſtiges of Nitre in it, which is detected by pouring in Oil of Vitriol to a perfect Saturation. For, if there remains any Nitre, this Reſidue will affect the Noſe with an

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* Large Quantities of Nitre are extracted at *Paris*, out of the Rubbiſh of old Buildings; which are there all made of Stone and Stone-mortar. The greateſt Quantities of Nitre, whereof the Conſumption is now become ſo great for the making Gunpowder, are brought from the *Eaſt-Indies*; but it is not yet known to us whether it is an artificial Compoſition made by the Inhabitants of the inland Countries, or whether there really are any Mines of native Saltpetre, or any natural Earths, out of which it can be extracted.

Odour of Spirit of Nitre, by expelling the Spirit of it. This Preſence of fixt Alkali in Nitre, is likewiſe teſtified by the Regeneration of it out of Spirit of Nitre and Alkali. Nitre agitated with a ſtrong Fire, in a ſtrong open Crucible, is at laſt diſſipated in Form of Smoak (*Proc.* XIV), there remaining a very ſmall Quantity of Alkali; which is, however, likewiſe diſſipated by continuing the Fire, becauſe it is not abſolutely fixt. Moreover, the ſuperfluous calcareous Earth, which has been introduced in a ſaline Form by the Spirit of Nitre, and is contained in the Lye, is precipitated by the fixt Alkali. This appears in great Quantities, eſpecially in the laſt remaining Lye of the firſt Cryſtallization, unleſs it has been already precipitated, during the boiling of the Lye itſelf, by the Abundance of Alkali: It is called *the white Mangane*ſ*e*. But we are informed, by dropping in Oil of Vitriol, that there is Spirit of Nitre in this Reſidue; and if it is diſtilled with this Oil, the collected Spirits are *Aqua Regis:* Becauſe there remains ſome common Salt in this Lye.

2. If Nitre is cryſtalized a ſecond Time, it is ſtill purer. The ſmall Clouds which appear at the Inſtant of the dropping in of the alkaline Solution, proceed from the ſmall Reſidue of white Manganeſe: But, the marine Salt is thoroughly ſeparated by this ſecond Operation, becauſe it being eaſily diſſolvible in Water does not turn ſo eaſily to Cryſtals, as Nitre: Therefore, the firſt Cryſtals are always purer than thoſe which are produced in the Cryſtallization of the Reſidue: Which is confirmed by the Diſtillation of this with Oil of Vitriol (See N°. 1).

3. Mean while, take Care, never to make the Evaporation and Cryſtallization of the Salts in an earthen-Veſſel: For, let it be glazed ever ſo neatly, yet, all Salts, even the fixt alkaline ones, are not only abſorbed thereby, but even find ſo ready a Paſſage through them, that lanuginous Cryſtals ſurround the Veſſel on the Outſide.

OF COMMON SALT.

PROCESS LXXVII.

To try ſaline Waters.

APPARATUS.

SAL-gem may be extracted ſimply out of Earths and Stones with warm Water. But ſaline Waters muſt be purified, by either Filtration, or Reſt. Let ſeveral Pints of them be inſpiſſated by a ſtrong Boiling, till a thin Pellicle, or ſmall Cryſtals appear on the Surface of the Liquor. Next, the Fire muſt be diminiſhed, that the ſaline Brine may be only middling warm, and ſmoak: The Cryſtals which were ſmall at firſt, will grow of a larger Size: They are of the Figure of a hollow, truncated Pyramid, open at the Baſis, made of a Heap of ſmall Cubes, which being become large at laſt ſink to the Bottom of the Solution. But, if you uſe a ſtronger Fire, the whole Surface of the Brine will be covered with an unformed ſaline Cruſt, which hinders all further Exhalation, unleſs you break and precipitate it to the Bottom. When it is ſo far inſpiſſated, as that the ſaline Cryſtals may be almoſt even with its upper Surface; you muſt decant the Brine from the ſubſiding Cryſtals, and this muſt be inſpiſſated in the ſame Manner: The Cryſtals of Salt being collected, and dried by a gentle Heat, muſt at laſt be weighed.

The Uſe and Reaſons of the Proceſs.

You may plainly ſee from theſe Proceſſes, how common Salt may be ſeparated from other Salts eaſily turning to Cryſtals, and chiefly from Nitre. For ſome Salts are difficultly and in ſmall Quantity diſſolved in cold Water, but they melt moſt quickly and in great Quantity in warm Water. Such are Nitre, Tartar, Tartar vitriolate, all Vitriols, Allum, *&c.* ſome of them melt eaſily enough and in good Quantity, equally in cold and warm Water; nay, even in the Air, when they have abſorbed the Moiſture of it: Add though they melt a little quicker in warm than in cold Water, yet the Difference is very ſmall. Of this Nature are, common Salt, vegetable fixt alkaline Salts, and even ſeveral neutral Salts diſſolvible in the Air. Therefore, the leſs the Difference of the Quantities of the Salts which are diſſolved both in warm and cold Water, is, the leſs Quantity of Cryſtals you will get, and on the contrary. You will underſtand this better, if illuſtrated by an Example. Let Nitre be diſſolved in cold Water, to a *Saturation*; and the Solution boil in an open Veſſel: The Water will be ſo diſpoſed by the Heat, as that a much greater Quantity of Nitre may be diſſolved, beſides what is already ſo: Which may be exaſily experienced. But, ſo ſoon as the Water begins to be diſſipated into Vapours, it at laſt diminiſhes to ſuch a Degree, that it can no longer contain all the diſſolved Nitre, which being then at the Surface which is leſs warm, is nevertheleſs firſt of all deprived of its Water, and expelled in Form of a ſmall Pellicle, which retards the further Evaporation. If you continue to inſpiſſate by increaſing the Fire, the whole Nitre turns to an unformed Maſs: But, if the boiling Solution is put in a cold Place, there remains as much Nitre in the Solution, as may have been diſſolved in that Degree of Cold, by a Quantity of Water equal to that which is in the Solution. The reſt is ſeparated in Form of Cryſtals, that is, above half of the Nitre, if the Atmoſphere is very cold; and leſs, if it is very warm. Apply the ſame to Brine. But as a cold and very ſaturated Solution of common Salt admits but very little more Salt, if it is made warm, the ſmall Cryſtals appear at the Surface, in the very Beginning of the Evaporation, and are very little increaſed when the Brine grows cold. Now, if you ſuppoſe that Solutions of Nitre and Salt are mixt together, and conſider, at the ſame Time, that the Salt will be better diſſolved by cold Water than the Nitre, you will eaſily conceive, why the Cryſtals of the Nitre are ſeparated, while the Salt remains in the Solution.

OF GLASS.

Our chief Deſign does not require that we ſhould give in the following Proceſſes a compleat Account of the Art of making Glaſs. It will not be uſeleſs, here to inſert only a few Proceſſes concerning Glaſſes tinged by Minerals, and to add thoſe Things which are neceſſary to underſtand the ſaid Proceſſes. For one has attempted to gueſs from the Colours which Glaſſes borrow from the Minerals that are mixt with them, what Kinds of Metals they did conceal. Therefore, you will plainly ſee from the following Proceſſes, whether this peculiar Kind of Trial may be done, and how far it may be carried.

PROCESS LXXVIII.

To try, how much Glaſs, the Caput Mortuum *of Cobalt or of Biſmuth, will be able to change into blue Smalt.*

APPARATUS.

1. CHUSE clean fuſible Sand, or Flints that are white, or at leaſt that can be rendered ſo by Calcination; put what Quantity of them you pleaſe into a Crucible, and expoſe it to a pretty ſtrong Fire: Pour the Maſs quite red-hot into a Trough full of cold Water. By this Means, the ſmall Stones will be ſplit, and rendered fitter for a more eaſy Pulverization: Pour out the turbid Water, and grind

your Stones thus prepared in a very clean Iron-mortar, or upon a very hard Piece of Porphyry, to a ſubtile Powder.

2. Take four Parts of this Powder, as much of Pot-aſh, or of ſome other alkaline fixt Salt well purified, and one Part of Cobalt well roaſted, or of eliquated Biſmuth-Ore, both likewiſe comminuted, and pound them together in a Mortar, that they may be thoroughly mixt: Let them melt for a few Hours in a well tried Crucible covered with a Tile, in a moſt violent Fire having a Draught of Air. When the Crucible is taken out of the Fire, cool it by ſprinkling it with Water, and then break it: Examine the ſmall Bits of Glaſs, whether they are opaque, of a very dark blue and almoſt blackiſh Colour; and finally, whether they are ground to a finer Powder, and appear of a pleaſant light blue Colour. If the Colour is too light, and the larger Bits of Glaſs almoſt tranſparent, you muſt add two or three Times more of *Caput Mortuum* of Cobalt, or of Biſmuth; ſubſtracting ſomething, if the Colour proves too deep.

3. If inſtead of the firſt Mixture, you uſe Glaſs pretty tranſparent, without any Colour, and already made of Flints and Salt, it will be the ſame Thing: But as this is refractory not only of its own Nature, but is alſo rendered ſuch by the Cobalt, it is proper to add moreover one third Part of Pot-aſh with reſpect to the Cobalt.

The Uſe and Reaſons of the Proceſs.

1. This Earth which tinges Glaſſes with a blue Colour, has been found only in the Cobalt of Arſenick and Biſmuth, and it may be known *ex tempore*, if you but melt it with two or three Times as much Borax, on Account of the ſpecifick blue Colour which it gives to this Salt. It is not metallick: At leaſt, Artificers have not been able, by any Methods hitherto-known, to extract any Metal out of them; unleſs there remains per-

whether ſimple or mixt in any Proportion and Manner whatſoever, whether calcined or joined to Glaſſes, differ very much according to the Degree and Duration of the Fire, which you have employed during the Calcination of the Metals, and the Fuſion of them with Glaſs when they are melted; ſo that it is hardly credible, that the ſame Glaſs, taken out of the Fire at different Times, ſhould appear under ſuch a Variety of Forms; nay, that the Colours of it ſhould vaniſh entirely. Secondly, there are Metals the *Calx's* of which give Glaſſes a light Colour, and others which being calcined make them of the deepeſt Dye: Whence it happens, that when ſuch Bodies are mixt together, the Colour of the one or the other grows quite obſcure, and vaniſhes entirely. But, there are ſeldom Ores, in which one ſingle Metal lies hid alone: And there are almoſt always two or more of them joined in the ſame *Matrix*, and in a Multitude of Ways, Proportions, and Qualities. But then the Colours reſulting therefrom, are of the greateſt Variety diſtinguiſhable again by the Eye, but impoſſible to be deſcribed, and ſo infinitely multiplied, that the moſt experienced Artificer could hardly indicate the leaſt Part of their Cauſes. Other Metals, on the contrary, will not manifeſt themſelves at all by any Colour, in ſuch a Mixture. Let there be, for Inſtance, Ores, in which Lead and Copper lie hid in many Proportions, the Copper, however, not being in too ſmall a Quantity therein. Melt one Ounce of cryſtalline Glaſs with a few Grains of this Ore: The Colour will prove of a bluiſh green Dye, and the Lead that was hidden in that ſmall Quantity of Ore, though it were ten Times more than the Copper, will not in the leaſt betray its Preſence by the Colour, nor will the ſpecifick Hardneſs and Weight of the Glaſs be ſenſibly increaſed by ſo minute a Quantity: If you add a great deal of the Ore, the Colour will be totally obſcured by the Copper. The ſame will, in this Caſe, take Place in Tin, Silver, Gold, and Antimony. Thirdly, there are other Bodies not metallick, which not only give Glaſſes the deepeſt Colours; but alſo reduce the deſtroyed Colours which had been firſt produced by Metals. Such are the *Capita Mortua* of Cobalt and Biſmuth, ſeveral Bodies merely terreſtrial, inflammable, fuliginous, *&c.* From theſe Matters of Fact it is plain, that theſe Vitrifications ought to be performed with the utmoſt Care and Circumſpection, and much more neatly than all the other chemical Operations; ſince they may be diſturbed by ſo many very ſmall and hardly perceptible Cauſes.

2. I ſhall, in favour of thoſe who love to make Experiments about Vitrifications, there ſhew in a few Words how they can be performed conveniently with the leaſt *Apparatus* and Expence: For which Purpoſe, I ſhall, to the beſt of my Power, here collect and mention what Authors have told us on this Matter, and what I myſelf am ſure of from my own Experience. The Authors who have given us the Things chiefly appertaining to our preſent Purpoſe, are *Antonius Neri*, an *Italian* Prieſt, on whoſe Works Dr. *Merret* has given us a Commentary, and tranſlated them from the *Italian* into *Engliſh*, and then into *Latin*. *Kunkel* has added Notes to both, more valuable than the two foregoing, as he has confirmed what was true, mended the Errors, and, what is much more, unfolded immenſe Difficulties by them left unravelled, the whole written in the *German* Language *.

The Furnace that is neceſſary for theſe Experiments, is repreſented in *Tab.* VI. *Fig.* I, II, and III, and deſcribed at the End of this ſecond Part. I have at laſt, by much Experience, ſo adapted this Furnace to theſe Operations, that a much more violent Fire may be applied to the Veſſels, and many of them be put at once into it, and the Roaſtings and Calcinations, here requiſite very long, may be performed in the ſame Fire. I ſhall then deſcribe this Furnace, ſo as that it may be eaſily conſtructed by any attentive Reader: And for the clearer Underſtanding of this Matter, I have given the Figure of it to be ſeen at the End of this Book.

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* But will ſoon be publiſhed in *Engliſh*, being already tranſlated by the ingenious Dr. *Hampe*.

For the Matter of it, chuſe Stones that will bear the ſtrongeſt Fire. You will eaſily obſerve this, if you uſe a Stone for the Support of a Crucible, in which, for Inſtance, a ſtrong Fuſion of Copper is performed: If this Stone does not adhere to the Bottom of the Crucible when it is taken out, nor looks to be run to Glaſs; except perhaps it has a very thin vitreous Cruſt, nor contracts Chinks, and preſerves its Hardneſs when grown cold, it is very fit for the intended Uſe. You may inſtead of Cement uſe a clayey * Matter, of which the ſame Stones, or Bricks †, and the docimaſtical Furnaces are made. But your Stones muſt be ſo fitly adapted to each other, that the thinneſt Stratum of Lute may be ſufficient to conglutinate them.

Let the Room in which it is to be conſtructed, have a Chimney that gives a rapid Motion and Draught to the Smoak: All the large Paſſages opening to the Air muſt be ſuch as may be ſhut, and the Furnace be made near this Chimney, in ſuch a Place, as that the Artificer may freely move round it.

The outward Figure of the Furnace may be cylindrical and arched at Top. Let the outward Diameter be twenty four, or more Inches, according to the Difference of the Stones; the Height muſt be forty eight Inches: The Thickneſs of the Wall, where it is thinneſt, muſt be four or ſix Inches at leaſt. The inward Cavity is divided into four Chambers, which are formed according to a parabolick Line. The lowermoſt ſerves for an Aſh-hole, and is twelve Inches high, and its greateſt Diameter at Bottom fourteen Inches. Whence the Deſcription of the Parabola is ſelf-evident. Let this Arch be open at Top

* Windſor Loam or Sturbridge Clay will anſwer this Purpoſe.

† Windſor Bricks.

with an Hole ten Inches wide; ſo that there may be left in the Back of it, a Margin two Inches broad round the Cavity of the Furnace. This Margin ſerves to ſupport priſmatical, quadrangular, Iron-Bars, which muſt be put upon the round Hole, inſtead of a Grate. Theſe Iron-bars are faſtened with a *Stratum* of the beſt Lute of the ſame Thickneſs of the Bars, at the Place where they reſt upon the Margin. This Lute muſt be neatly ſmoothed, that ſmall Veſſels may be ſet upon it all round. Leave at the Baſe of the Aſh-hole, a ſquare open-Door, ſix Inches broad, four Inches high, with an Iron Door hung on Hinges.

The other Chamber built upon the foregoing, is a fire-Place to put in the Fuel of the Fire, and of the ſame Breadth and Height as the foregoing; unleſs the Stones it is made of are leſs durable in the Fire: For, in this Caſe, it muſt be a few Inches broader, and be covered over with a Cruſt as many Inches thick, of the beſt Lute that will bear the ſtrongeſt Fire. Let the Top of the Arch be perforated with a round Hole ſix Inches in Diameter, round the Circuit of it the Arch muſt not be thicker than a Finger's Breadth. Let there be upon the Back of this Arch a Pavement four Inches broad, to put the Veſſels upon. Make in the Circumference of this Chamber ſeven equidiſtant Doors, ſix of which muſt be four Inches broad, and as much high, and the ſeventh two Inches larger, all of them arched at Top. Let the Baſes of them be the Height of two Inches diſtant from the Margin upon which the Iron-Bars are fixt, which Margin muſt be conſidered as the Pavement of this Chamber. Let the Wall at the Baſis of each Door, and at the above-mentioned Interval, be cut out on the Inſide to one third Part of its Thickneſs. But, let all the Doors be of Iron, hung on Hinges, and made in the ſame Manner as *Part* I. § 239. N°. 4, coated two Inches thick. When ſhut, they muſt be received into a Groove, cut on the Inſide in the Wall, of the ſame Depth as that of the coated Door, and but a few

Lines broad: Let there be beſides a ſmall Hole at the Top of each Door, that one may conveniently look into the Furnace.

The third Chamber built over this, is perfectly like the two foregoing, except that the Arch is a few Inches lower, and there is a quadrangular Hole communicating from this Arch into the fourth Chamber, not in the Middle but towards one Side, and cut equilateral, being four Inches ſquare.

The fourth and laſt Chamber is arched, equal in Breadth to the foregoing, and only eight Inches high. On the Side oppoſite to the Hole which from the other Chamber communicates into this, at the Height of two Inches above the Pavements, let there be a cylindrical Funnel, made of an Iron-plate, and four Inches in Diameter, which leads the Smoak, and the Flame into the Chimney of the Room. Let a Paſſage into this Chamber be open, through a Door ſix Inches wide, and as much high, juſt above the Pavement of the Chamber, opened in the Middle of the Circumference, between the quadrangular Hole and the Funnel. To which Aperture let an Iron-door be hung, that the Veſſels may be conveniently introduced, and taken out.

Uſe this Furnace in the following Manner. Make a Fire in the ſecond Chamber: And uſe for your Fuel Charcoal or Wood very dry, eſpecially Beech, which muſt be put in through the largeſt Door of this Chamber. As to the Choice of the Fuel for the making of a ſtrong Fire in general, obſerve what follows. If you have a Mind to urge with the ſtrongeſt Fire a Body ſurrounded on all Sides with Fuel, you muſt in this Caſe chuſe the Coals that are of a ſmall or middling Size, nor muſt you put between the Grate and the Veſſel which contains the Body to be changed, a Support higher than three Finger's Breadth, if the Veſſel is very large; nor lower than one Finger's Breadth, if it is very ſmall. But, if the Veſſels are put at the Side, or above the Fuel, as is moſt commonly done in this

Furnace, that they may be expoſed to a ſtrong Heat, and to a very quick Flame, you are to chuſe larger Pieces of Wood and Charcoal. Now, if you open in the Wall of the Room, a Hole ſomewhat larger or at leaſt equal to that which is at the Bottom of the Aſh-hole, and make a Pipe or Trunk of Iron-Plates leading from the former into the latter, and on the other Hand ſhutting the Room very cloſe all round, that the Air may not ruſh in too freely; then, the Blaſt of Air that paſſes through this Trunk, is the ſtronger, as the Chimney of the Room grows the warmer: Whence the greateſt Degree of Fire produced by a Draught of Air, is at laſt obtained. But the Fire will be of the utmoſt Strength at the ſmall Doors of the ſecond Chamber, ſo that a few Ounces of Copper being flung without any Addition into a Crucible that is red-hot there, will melt in a Minute, being agitated by a Fire greater than is neceſſary for the pouring of Copper into a Mould, to repreſent any certain Figure. The Veſſels are put in through the ſmall Doors, and are put upon the Margin, whereon the Iron-Bars which form the Grate, are placed. You may place as many Veſſels round the Circumference of the Chamber as there are Doors in it. The Veſſels which are put in, before the Furnace is perfectly warm, may be put upon a low Support, made of a Stone one Inch thick, and not eaſy to be vitrified. You may ſee and try the Matter in the Veſſels, through the ſmall Hole made in each of the Doors that are hung on Hinges. In the third Chamber, you may, on Account of its Pavement's being much broader, put a double Row of Veſſels therein, that is, twelve in Number, or more, if they are of a middling Size. The Fire is milder in this Chamber than in the foregoing, *viz.* a middling melting Fire. Finally, the Fire is much more gentle in the fourth and uppermoſt Chamber, and is of very great Uſe for Calcinations and Roaſtings, to be made in a middling Fire: But then, indeed, the Veſſels do but grow red-hot there. If you have a

Mind to put your Veſſels in the Furnace already hot, they muſt be previouſly made very warm; then, they are able to bear the Heat in the fourth Chamber, out of which they may at laſt be put into the Third or Second, when they are already red-hot.

You muſt, before this Furnace is conſtructed, make an *Apparatus* for ſeveral Operations: And thus you will perform a great many Experiments, with very little Trouble and Loſs of Time: So that I can aſſure my Readers, that none have been more agreeable to me than thoſe I have made in this Furnace, though they are extreamly tireſome by any other Method, on Account of the ſtrongeſt Fire which muſt be continued ſo very long. I do not indeed exaggerate, in ſaying that all the Operations are twice as eaſy, when you know how to make a right Uſe of this Furnace.

For want of it, I formerly uſed with ſome Succeſs the Athanor deſcribed (*Part* I. *Plat*. IV. *Fig*. I.) by applying to the Aſh-hole of it a Wind-pipe, like that applied to the foregoing: I put the Veſſels that were ſet upon low Supports, into the Chamber next to the Tower: I took quite away the Iron-Lamina which intercepted the Paſſage of the Fire: I ſtopt the fore part of the Chamber, with a Wall made of Cement and Brick, in which I left two ſmall Doors, to introduce and take out the Veſſels, which Doors might be ſhut with Stopples. I placed the Veſſels to which the ſtrongeſt Fire was to be applied, next to the Hole which conveyed the Fire from the Fire-place that was in the Tower, into this Chamber: And thoſe which required a more gentle Fire, I placed in the Middle, and over-againſt the foregoing: But, as the Stones were not of the beſt Kind, and the Fire, continued for two Days together, was moſt violent, the Furnace was almoſt deſtroyed, and the Supports of the Veſſels almoſt immerſed in the vitrified Stones; though no Glaſs had run out of the Veſſels: Which muſt be prevented with all imaginable Care; for, if it happens ſo a Number of Times, your Furnace will be totally deſtroyed.

They uſe for their Veſſels in Part common Crucibles, and melting Diſhes, which are put into the Furnace either open, or covered with Tiles. But, if you have a Mind often to try and ſtir up the Matter within them, and are at the ſame Time to avoid the falling of Aſhes, which fly about, into the Veſſels, you muſt make an Hole in the upper Part of the Veſſel on one Side, and then cover it with a Tile to be faſtened with Lute. You may alſo make on Purpoſe ſmall cylindrical Veſſels *, ſhut cloſe at Top, having a like Aperture. If they are put into the Furnace, their Opening muſt look towards the Door. If you uſe triangular Veſſels, the Angle muſt look towards the Centre, and the oppoſite Side towards the Door: For, if you neglect this, the Veſſels will eaſily ſplit, as they are put in. Therefore, we will omit all the Methods of making figured Glaſſes; only the Compoſitions of them.

We have already given a general Definition of Glaſſes (*Part* I. § 8. *Schol.* 451—2.) They are in part *the ſimple ones*, which may again be ſubdivided, 1. Into merely *terreſtrial*, to which Claſs all the vitreſcent Stones do belong, and it is all one whether they are crude or already melted: For, the crude vitreſcent Stones have all the Characteriſticks of Glaſs. 2. Into *metallick*, that is, the Metals and Semi-metals; all of which, except Gold, Silver, Mercury, and Arſenick, turn to *Calxs* properly ſo called, by Means of a gentle Roaſting, and into Glaſs at laſt, by applying a ſtronger Fire to them. They are alſo in part *compounded ones*. Now they are compoſed either of the ſimple Ones juſt mentioned, or alkaline and neutral fixt Salts are added to them, of which we are going to treat in a more ſpecial Manner.

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* Of Sturbridge Clay.

PROCESS LXXX.

The making of common Glaſs, and the Extraction of Salts out of Aſhes, for the preparing of it.

APPARATUS.

1. ALKALINE fixt Salts produced out of burnt Vegetables, melted together with vitreſcent Earths, turns to what is called common Glaſs. The alkaline Salt, with its *Matrix* Earth, that is, Salt-aſhes remaining after the burning certain Vegetables, being melted in a ſtrong Fire, turn to Glaſs, with which you may likewiſe melt a Quantity of Sand, or of pulverized Flints, which may be in greater Proportion, as the Aſhes were more Salt. This Glaſs is the hardeſt of all, more refractory in the Fire than the other common Glaſſes, perfectly reſiſting the Air and Water, and all liquid *Menſtrua* that are known: On which Account it is not to be eſteemed leſs than the fineſt cryſtaline Glaſs, becauſe of its vaſt Uſefulneſs. Its Colour is commonly of a dark green Dye, ſometimes quite opaque and black. The Reaſon of this incomparable Durableneſs conſiſts in the perfect Mixture of the Salt and the Earth, as likewiſe in the great Quantity of the latter, whereby it ſurpaſſes the former much more than in any other Glaſs. Salt, for Inſtance, is moſt equally and minutely divided through the Aſhes; whence its diſſolving Virtue is ſo much increaſed, that this little Quantity of Salt is able to bring ſo great a Quantity of a very refractory Earth, to a State of Fuſion. The Aſhes being deprived of all Salt, by repeated Roaſtings and Edulcorations, and rendered ſo pure as to be uſed for the making of Coppels, if you mix them again with their proper Salt, and put them in the ſtrongeſt Fire fit for melting Glaſs, it will never

be poſſible to bring them to ſuch a Degree of Fuſion, as that tractable Glaſs to be figured by blowing, may be made out of them; though this Salt lying ſtill hidden in its own Earth of the ſame Kind, was able to diſſolve not only the ſaid Earth, but alſo one third Part, and even more, of the Sand which had been added over and above.

2. To make clear common Glaſs more tranſparent, you muſt extract the Salt out of the ſaline Aſhes of any Sorts of Vegetables. But you muſt chuſe Vegetables that have been gathered in their perfect Growth, not expoſed long to the Injuries of the Air, nor very old neither: For, the Rains and the Air itſelf at laſt waſh off and conſume that, out of which fixt alkaline Salt is afterwards to be produced by Fire. Nor can you even produce out of all Vegetables, a Quantity of fixt Alkali that will repay your Charges and Troubles: You muſt conſult the Experiments of Chemiſts upon this Matter. All theſe Salts are perfectly the ſame, after they have been duly purified, as is obſerved by *Kunkel:* For this Reaſon, it is altogether needleſs, to prepare, for the compoſing of Glaſſes, ſo many Salts, ſo difficult to be got, and on this Account ſo very dear: Since a ſingle Kind of Salt extracted out of the vileſt Vegetable, is as good and ſufficient for your Purpoſe, as all the others together *. The extraction of Salt out of the Aſhes, and the Purifying of it is performed, 1. By Solution in about three Times as much warm Water, with which the Aſhes muſt boil for a while, and be ſtirred now and then with a wooden Stick. 2. By ſtraining through a filtrating Paper, or through a Linnen-bag: Which muſt be repeated by pouring back the Water over and over again, till the Lye paſſes through quite clear. 3. By Evaporation, which is performed in an Iron-pot well cleaned of all Ruſt. During the Evaporation, you are to avoid that any Aſhes ſhould

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* The Sea weeds, eſpecially that Sort called *Kali* or Glaſswort, abounds moſt with this Sort of Salt.

fall into it, and you muſt make under it a Fire that makes it boil gently: But you muſt firſt have a ſufficient Quantity of Lye ready, that you may be able to fill the Pot eight or ſix Times at leaſt. Nor muſt you pour more at once than is neceſſary that the Pot may be half-full, leſt the Salt ſhould form a Cruſt in the upper Part of the Pot, that would be difficult to ſeparate. As much Water as is diſſipated by Evaporation, ſo much freſh Lye muſt be now and then poured into the Pot. When the ſmall Clots of Salt begin to thicken, and to appear in the Lye, and a ſmall ſaline Cruſt covers the Surface of it, diminiſh the Fire, and with a Wooden-ſcraper, or an Iron-ladle, ſtir it circularly, till there remains a dry pulverulent Salt. When you ſee this, you may bake it quite dry, without any further ſtirring. If you neglect this ſtirring, and the Diminution of the Fire, a very hard Cruſt of Salt will apply itſelf to the Pot, which cannot be ſeparated but with a Mallet and a Chizzle and not without a Mixture of ſeveral Particles of Iron, by which violent Percuſſion, the Pot which is of melted Iron, and brittle, is frequently ſplit. Mix two Parts of this Salt, which will be brown, or ſomewhat yellow, with three Parts of pulverized Flints, or of Sand; melt them together in a great Fire, in which the Mixture being left for ſeveral Hours, will turn to a Glaſs finer than the foregoing, but leſs durable; becauſe it contains much more Salt, and the Mixture is not ſo perfect. But we cannot determine a conſtant Proportion of the Flints or Sand, and the Salt, becauſe of the Variety of the Stones. For ſome Flints are more fuſible than ſome others: It is the ſame with the different Kinds of Sand; which muſt be evinced by Experiments. Salt produced in an Earthen-pan, put immediately into the uppermoſt Chamber of the Furnace, or in its Pavement, and calcined with only a gentle Fire, leſt it ſhould melt, and freed of a great Quantity of Fat which it ſtill contains, will become perfectly white: Or, if you have uſed too ſtrong and long-laſting a Fire, it will aſſume a light bluiſh and greeniſh Dye, with which you will afterwards make a Glaſs more beautiful, more tranſparent, and more free from all Colours than the foregoing. But a ſtrong Fire continued long, very much promotes this Beauty and Duration. A more perfect Mixture is obtained, and the ſuperfluous Salt diſſipated by the ſame; becauſe the fixt Alkali vaniſhes in form of a white Smoak: But, it is impoſſible to diſſipate it intirely: For, part of it is moſt intimately joined by the Flints. Thence now it is plain, why Glaſſes of different Degrees of Beauty and Durableneſs, are produced out of one and the ſame Mixture, it proceeding from the different Degrees of the Strength and Duration of the Fire. For Glaſſes taken ſuddenly out of the Fire, grow obſcure of themſelves in the Air, and ſometimes fall aſunder into Powder, though the juſt Proportion of the Stones and Salt has otherwiſe been obſerved: Which will alſo happen the ſooner, if there is more Salt in the Mixture than is requiſite.

PROCESS LXXXI.

The Preparation of the Salts, for making of cryſtalline Glaſs.

APPARATUS.

IF you are willing to have the fineſt cryſtalline Glaſſes *, you muſt purify your Salt ſeveral Times by Solution and Cryſtallization. For the coarſer Earth is not ſufficiently ſeparated by the firſt Solution; though you ſhould ſtrain your Lye through the denſeſt Filters. Therefore, you muſt diſſolve your Salt (*Proc.* LXXX.) a ſecond Time, and purify the Lye by Filtration; then inſpiſſate it in the ſame Manner in the cleaneſt Iron-pot, till the Lye be at laſt ſo thick, as that a thin ſaline Cruſt begins

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* Commonly called white flint Glaſs.

PROCESS LXXXIII.

The Compoſition of cryſtalline Glaſs.

APPARATUS.

WE have already obſerved, that it was impoſſible to aſſign a conſtant Proportion in the compoſing of Glaſſes, on Account of the different Degrees of Fuſibleneſs in the Flints; therefore, we ſhall here inſert a few Preſcriptions, by way only of Specimen.

Take of prepared Flints pp. VIII. of the pureſt alkaline fixt Salt pp. V.

Otherwiſe: Take of prepared Flints pp. III. of the pureſt alkaline Salt, and of burnt Borace p. I. each.

Otherwiſe: Take of prepared Flints pp. III. of the pureſt Nitre pp. II. of the pureſt alkaline Salt, and of burnt Borax p. $\frac{1}{2}$ each. Of white cryſtalline Arſenick p. $\frac{1}{16}$.

If you add Arſenick, it muſt firſt be intimately mixt with the Salts, eſpecially Nitre, and this Mixture be joined with the Flints. The Effect of Arſenick here, is, that the Salts diſſolve the Flints with greater Efficacy: And it does not entirely evaporate, as has been already obſerved, but being in great Part fixt by the Glaſs it ſuſtains the moſt violent Fire. Whether it alſo takes away the greeniſh and bluiſh Colour of Glaſſes, if ſuch a one is produced by the Impurity of the Flints or Salts proceeding from a Mixture of metallick Particles, and in what Manner it does it, if this be the Caſe, muſt be evinced by a further Inquiry.

If you have a Mind to melt theſe Mixtures, chuſe a very clean Veſſel, ſhut cloſe at Top, that no Filthineſs may fall into it, having a ſmall Hole on the Side, that the Maſs within may be examined. But, before the Matter is put into the Veſſel, this muſt firſt be baked, and glazed with a vitreous Cruſt of Litharge. This is done by putting Powder of Litharge into the ſmall Veſſel ſtill moiſt before the baking of it, ſhaking it in the Veſſel and expoſing it to a moderate Fire, after having thrown out what is ſuperfluous; Which may be done in the third Chamber of the Furnace. Thus you will preſerve your Glaſs from being tainted by ſmall Stones and Duſt looſely adhering to theſe Veſſels, which are then faſtened by the Litharge. Every Thing being thus prepared, fill two Thirds of the Veſſel with one Compoſition, and before you expoſe it to the ſtrongeſt Fire, roaſt it for an Hour in the fourth Chamber, then put it into the Third or Second, that it may melt thoroughly, there it muſt ſuſtain a long Fire, till it is ſufficiently fine, and free from Bubbles: Which requires the Space of ſeveral Hours. To try this, touch the Surface of the melted Glaſs with a new Tobacco-pipe, to which a ſmall Portion of Glaſs will adhere when you take it out. Take Care, in making this Trial not to move your Glaſs: For as often as you do this, it contracts new Bubbles; which cannot eaſily go away in ſo tenacious a Maſs. If theſe Glaſſes are left long enough in the ſtrongeſt Fire, they are harder and more tranſparent than any. If you will have large Bits of it, it muſt be moſt ſlowly cooled in the fourth Chamber, and the Veſſel be broken, or be ground away upon a grinding Stone, in the Place where it is contiguous to the Glaſs.

PROCESS LXXXIV.

To tinge Glaſſes by Metals, and other Bodies.

APPARATUS.

WE have already given Specimens about theſe Glaſſes (*Proc.* LXXIX.) where we laid down the general Obſervations to be made on this Matter: We muſt now treat of them in a more ſpecial Manner. The Preparation of the *Calx* of Metals wherewith

with Glaſſes are tinged, require a Variety of Menſtrua, according to the Variety of the Metals.

The Calcination of Iron and Copper is performed almoſt by the ſame Things, the principal of which are: 1. Fire alone, which deſtroys the Metals called imperfect, and even Iron itſelf very eaſily without melting, and Copper more eaſily ſtill: This is done in a ſhort Time, if you reduce thoſe Metals to thin Plates, or to Filings, and put them in a Veſſel covered with a Tile, into the third Chamber, where they are left, till they become perfectly triturable. When triturated, let them be calcined once or twice over for half a Day or more, that all the ſmall Maſſes which poſſibly have preſerved their metallick State, may be burnt. Let the Fire never be ſo ſtrong, as that the *Calx* may have any Diſpoſition to a State of Fuſion. 2. Let the pulverized Sulphur mixt with Iron-filings, be expoſed for a few Hours to a ſtrong Fire, in a covered Crucible, in the third Chamber. Let the Filings be corroded, that they may become triturable, and the triturated *Calx* be roaſted for one or two Days in the fourth Chamber. It will thus turn to *Colcothar* of a dark red Colour, fit to tinge Glaſſes. This Action of Sulphur is ſtill quicker upon Copper than upon Iron: For pretty thick Plates of the former ſtratified with pulverized Sulphur in a cloſe Crucible, being expoſed to a middling Fire in the third Chamber, are penetrated in a few Hours, and rendered brittle, much thicker, and of a dark Colour; and when pulverized afterwards, put into the fourth Chamber in an open Veſſel, they are roaſted for a few Hours, that the remaining Sulphur may be diſſipated. Thus you will have *Calx* of Copper prepared with Sulphur. 3. Oil of Vitriol diluted with Water, quickly diſſolves Iron, and turns to Vitriol together with it: A ſmall Quantity of Copper is more difficultly diſſolved by it (See *Proc.* LXXIII). The Cryſtals of Vitriol made by Evaporation, being dried over a warm Oven, fall into Powder, which muſt again be roaſted in the fourth Chamber, edulcorated with warm Water, dried, and kept ſuch for Uſe. 4. If you ſprinkle Filings of Iron or of Copper, ſeveral Times, with diſtilled Vinegar, and dry them again over a warm Oven; they are both corroded, and the former turns to a triturable dark aſh-coloured Powder, and the latter into a green Ruſt.

Braſs is calcined by Fire alone, but being much more conſtant when made red-hot, than pure Copper (*Proc.* LXVI), you muſt calcine thin Plates of it in a ſtrong Fire, in the third Chamber; taking Care, mean while, that they do not melt: Becauſe it, on the contrary, melts much more quickly than pure Copper. This *Calx* muſt be roaſted again ſeveral Times, in a milder but long-laſting Fire.

Lead is calcined, 1. without Addition, if you melt it in a large Iron-ladle: It preſently contracts a ſmall Skin at the Surface, which muſt be taken off and thrown away with an Iron-ſcraper: For Copper, if there is any in the Lead, likewiſe contains in it the Filthineſs which adheres to Lead: Another ſuch Pellicle will ſoon be produced: Which muſt be taken off, and kept: Continue thus to collect the Pellicles produced in this Manner, till you have gathered a ſufficient Quantity: Let them be extended wide in the fourth Chamber, and roaſted in a gentle Fire, ſtirring them now and then with a ſmall Hook, till they become perfectly triturable. 2. Lead is, by the Vapour of Vinegar, corroded to a white *Calx*, which being pulverized under the Name of Ceruſe, is ſold very cheap in all Perfumers-ſhops, but proves ſeldom genuine, and is often mixt with Chalk, Parget, and other Things: Whence the Glaſs-makers who uſe ſuch Ceruſe to make Glaſs of Lead, loſe both their Labour and Materials. If you are willing to prepare the beſt Ceruſe of this Kind with Vinegar, diſtil Vinegar of Wine, out of a Cucurbite through an Alimbeck full of thin Plates of Lead, and ſo diſpoſed, that the ſmall Drops which apply themſelves to them, may neither fall into the Cucurbite, nor run down again, but be all collected in the Channel of the Alimbeck, and thence run down through its Neck into the Recipient applied to it. Let the Diſtillation be performed in a gentle Fire for a few Days: The Vinegar ſaturated with Lead and dulcified, will be collected in the Recipient. Being inſpiſſated according to Art it forms a Heap of Cryſtals called *Saccharum Saturni*, *Sugar of Lead:* Theſe being calcined in a gentle Fire, fall into a white Powder, which is very uſeful for Glaſſes. *Calx* of Lead made red in an open reverberatory Fire, and called red-Lead, or the Litharge commonly ſold, may be ſubſtituted for the foregoing. But, as the latter in particular, commonly leaves the *Regulus* of Lead at the Bottom of the Veſſel; it muſt be melted, before it is added to the Mixture for the making of Glaſs, and then poured into the melting Cone, and the precipitated *Regulus* of Lead muſt be ſeparated, or the Mixture prepared for Glaſs be poured into Water, if it has been only a Quarter of an Hour in Fuſion; and the Lead be thus ſeparated from the pulverized Glaſs. Therefore, it is alſo proper, to mix with thoſe Glaſſes to which Litharge or any other Calx of Lead is added, a Portion of Nitre, which deſtroys the Lead, and vitrifies it ſoon. For Litharge conſiſts of very ſubtil Scales, and of ſmall Maſſes of Lead outwardly vitrified.

Tin is ſtill more eaſily calcined than Lead by the firſt Method, and with a ſtronger Fire; otherwiſe, it is ſooner prepared by the following Method in particular. When your Tin has been melted in a Crucible by a gentle Fire, add to it half as much Lead: This done, increaſe the Fire by degrees. So ſoon as it begins to grow red, the Tin is rejected out of the Mixture, in form of a Calx of different Colours. Continue the ſame Degree of Fire, till this Calx ſmoaks no longer, but ſparkles: Then take it away with an Iron-Ladle. The like will be produced again ſeveral Times. When it is collected, burn it quite in the fourth Chamber of the Furnace: But, it will not be altogether free from Lead.

The *Calx's* of Gold and Silver are prepared by Solution in their proper acid *Menſtrua*; from which they are ſeparated by extraction of the Spirits, or by precipitation with other Metals or Salts. Mean while, be aware of fulminating Gold. *Calx* of Gold precipitated out of *Aqua Regis* by Tin, is called *Calx Caſſii*. Mercury itſelf being corroded by *Aqua Fortis* and Oil of Vitriol, is rendered more fixt, and when inſpiſſated, it is ſometimes added by Artificers, to Compoſitions of Calxs for tinging of Glaſſes. Semi-metals are calcined by themſelves, which is eaſily done chiefly with *Regulus* of Antimony, or diſſolved by Acids, and precipitated ſeveral Ways: Nay, when prepared with Nitre by Detonation, they may enter into the Compoſition of Glaſſes.

Having prepared theſe Calxs, you will be able to tinge Glaſſes in a Multitude of Manners; eſpecially if they are at the ſame Time accompanied with ſome other Bodies.

Obſerve in general. 1. You muſt put your Mixture either in a new Veſſel, or at leaſt in a Veſſel in which Glaſs has been in the ſame Manner coloured, worked, melted, and taken out. 2. The thicker Bits of Glaſs require leſs of the tingent Calxs, and the thinner Ones require more. 3. Uſe a Fire of ſuch a Strength, as that a warm Tobacco-pipe being introduced into it, there may indeed adhere to it a pretty thick Cruſt, but not a large Knob of Glaſs: Nor muſt the Mixture be put at once into the Veſſels; but when part of it is thoroughly melted, the reſt may be put gradually into the Veſſel with a ſmall Iron-Ladle; For ſome Mixtures are very apt to foam: Of which we ſhall ſoon give Examples.

1. The green Colour is made of two Ounces of the Mixture for cryſtalline Glaſs, to which you are to mix about ten Grains of any Copper whatſoever, or of Braſs: If you add to the Calx of Copper a few Grains of *Crocus* of Iron, you will have the fineſt

Glaſs of a yellowiſh green-Colour. Thence, you will be able, by changing the Proportion of theſe two Calxs, to vary this Colour in an infinite Number of Manners.

2. Glaſſes are tinged with blue by Smalt, by Zaffre, or by Cobalt itſelf, previouſly roaſted, by mixing three or four Grains of it, with two Ounces of Glaſs.

3. Your Glaſs is brown or black, if you mix with it a great Quantity of Cobalt or of Zaffre, for Inſtance, one Drachm. The *Croci* of Iron, and all its Ores, have the ſame Effect, if you melt them together in a good Quantity with Glaſſes. Nevertheleſs, there is a Variety in this brown Colour: Eſpecially, if they are finely divided: For, then, the blue Colour of the Smalt, and the ruſty Colour of the Iron, may again be diſtinguiſhed.

4. You give Glaſſes a golden Colour, by adding to the Doſe of the above-mentioned Mixture, twelve Grains of roaſted Manganeſe, a Drachm and a half of Tartar, and ſix Grains of Charcoal-duſt, or of Soot.

5. White, milk-coloured, opaque Glaſſes are prepared with Tin, by adding to your Mixture for Glaſs one fifth Part of Calx of Tin, to which the ſame Quantity of Calx of Lead muſt be added for a more eaſy Fuſion, with one Grain of roaſted Manganeſe.

6. If you melt with Flints alone, the double or treble Quantity of Calx of Lead, you will make a moſt beautiful Glaſs, of a yellow Colour with a ſlight greeniſh Caſt, more fuſible than the foregoing, that will ſoon reject its Bubbles, and caſts up all the ſmall Stones: You may alſo add Calx of Lead to the foregoing Mixtures. Such Glaſs will have the foregoing Colours in a very elegant Manner. Calx of Tin added in an equal, or a double Quantity, renders them of a milk Colour, and they may be moſt finely tinged, if you add moreover *Calx's* of other Metals. Such opaque and moſt fuſible Glaſſes, made of Calx of Lead, of the Mixture for cryſtalline Glaſſes, and of Calx of Tin moſt finely mixt together, and tinged together by *Calx's* of other Metals, are called *Encauſta* (Enamells.)

(Enamells.) *Amauſa*, or Smalts. You may read ſeveral Things concerning theſe Matters, in the above-mentioned Authors.

PROCESS LXXXV.

Of hydroſtatical and ſtatical Examinations of Metals and Minerals.

APPARATUS.

THIS, as well as the foregoing Proceſſes, concerning Glaſſes, ſtrictly ſpeaking, do not, indeed, belong to the Art of Aſſaying. This Examination is performed by ſeveral *Apparatus's*, which you will find deſcribed in the hydroſtatical Writers, among which you may chuſe that, which, from Uſe and Compariſon, you will judge to be moſt convenient *. Make the following Obſervations in general.

1. Have at hand Water diſtilled in a Glaſs-veſſel on a gentle Fire, that may ſuſtain a Solution of Silver or of Lead, without being turbid: For, fountain, river, and rain-Waters, are too different.

2. Let the warmth of the Water and of the Body to be weighed, be fixt: For, it may occaſion a very great Difference: Which appears preſently, if you weigh in the ſame Water made warm, the ſame Body that has been already weighed. For, it will appear ſpecifically heavier: Therefore, you muſt be provided with a Thermometer. But, you muſt chuſe a Degree not exceeding much the greateſt Summer-heat, for Inſtance 90, according to *Fahrenheit's* Thermometer. You muſt warm to the ſame Degree not only the Water, but alſo the Body to be weighed; which may be very well done in a *Balneo Mariæ*.

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* Particularly the *Medicina Hydroſtatica*; or Hydroſtaticks applied to the *Materia Medica*, to which is ſubjoined a previous hydroſtatical Way of eſtimating Ores, by the Honourable *Robert Boyle*, Eſq; F. R. S. *Lond.* 1690. in 8vo.

3. You muſt firſt weigh the Bodies in the Air, in the moſt exact Manner.

4. Porous, ſinking Bodies, which abſorbe Water, muſt previouſly be moiſtened in a ſhallow Veſſel, full of very clean Water, to expel, as much as poſſible, the Air out of the Interſtices. For, it renders Bodies ſpecifically lighter; but, the Water that fills the Interſtices of the Body to be weighed, is indifferent with regard to the Water that ſurrounds the Body. But, when Bodies are moiſtened, they muſt not be immerſed in the ſame Manner, but they muſt be contiguous at Top to the Air. For, by that Means, the Air inherent in the Interſtices of this Body, will retire quicker, and more compleatly.

5. And as ſome Bodies do in a Manner reject Water, and ſmall aerian Bubbles, that render Bodies lighter, are produced at the Surface of almoſt all ſolid Bodies, while they are immerſed in Water, eſpecially warm Water; they muſt be moiſtened as ſoon as poſſibly you can.

6. Therefore, you muſt as much as poſſible, give the Bodies to be weighed a ſmooth and neat Outſide: For Inſtance, Metals reduced to a globular Form, may very eaſily be weighed by this Method.

7. Bodies full of Hollows, and concealing Air within themſelves, muſt be reduced to a Powder, which muſt be ſoaked in Water for a good while, and now and then ſtirred before it is weighed.

8. Salts muſt be weighed either in Alcohol (and they muſt all of them have the above-mentioned Degree of Heat) or, if they are diſſolved in Alcohol; or, if you have none at Hand, you muſt make a Brine thoroughly ſaturated with the ſaid Salts, with an undetermined Degree of Warmth, and compare the ſpecifick Weight of it, by Means of a ſolid Body, for Inſtance of Glaſs, immerſed in it, and afterwards immerſed in Water: Which Weight muſt be compared with that of the Water.

The other *Encheireſes* depend upon the Quality of the Inſtruments employed, and upon your own Practice.

9. Metals are more exactly weighed ſtatically, if you weigh firſt a certain Maſs of the ſame Metal rendered perfectly pure: Which is very well done, by drawing it into a ſlender cylindrical Wire, and by cutting out of it a Cylinder of a certain Length, which muſt be weighed in a docimaſtical Balance. Thus you may compare all malleable Metals drawn to Wire. You will be able to conclude from an hydroſtatical and a ſtatical Examination, the Purity chiefly of Gold, as being the heavieſt, and of Tin, as being the lighteſt of all Metals.

EXPLANATION
OF THE
FIGURES.

PLATE I.

FIG. I. A Peſtle, *to ſtamp the Coppels with. It is called in German* Munch.

a. b. *Its wooden Handle, which is faſtened into the hollow Braſs Cylinder in the lower Part of it.*

c. d. e. f. g. *The braſs Part of the Peſtle which is preſſed down into the Ring* FIG. II. *filled with Aſhes, to make the Cavity and Upper-border of the Coppel* (§ 177.)

e. *Is a ſpherical Segment very well poliſhed, which correſponds to the Cavity of the Coppel.*

d. f. *Is a projecting Border, which forms that of the Coppel.*

c. g. *Is the hollow braſs Cylinder, into which the Handle* a. b. *is received.*

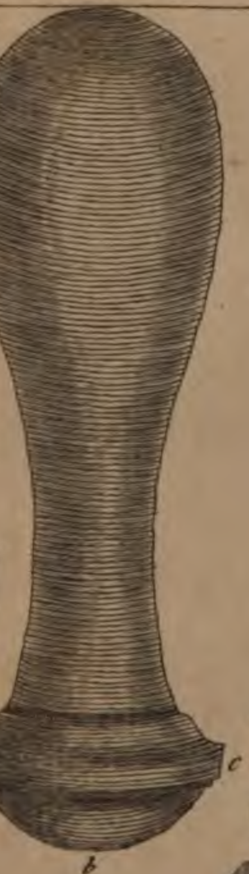
FIG. II. *A braſs*-Ring, *called in German* Nonne, *drawn according to the perpendicular Section, repreſenting a truncated Cone, open at Top and at Bottom, which is filled with the Aſhes to be preſſed down with the Peſtle* FIG. I. *The pricked Lines mark how deep the Peſtle muſt be thruſt, before its Border* d. f. *reaches the Sides of the Ring.*

It is proper to have ready at Hand three or four ſuch Rings of different Sizes, with Peſtles correſponding to them. The leaſt of them muſt form a Coppel, of $\frac{3}{4}$ *of an Inch; the largeſt of them muſt form a Coppel two Inches, from out to out.*

FIG.

Pl. I.

Fig. V.



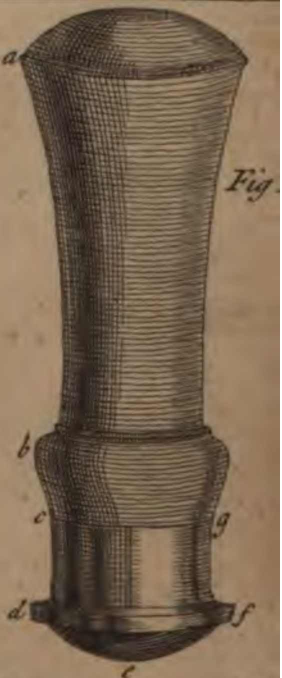
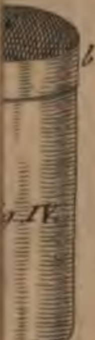


Fig.



g. IV.

VII.

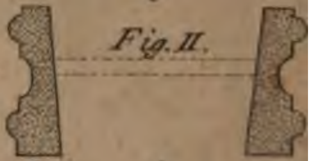


Fig. II.

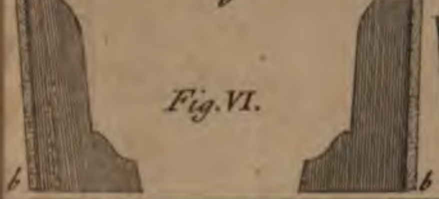


Fig. VI.

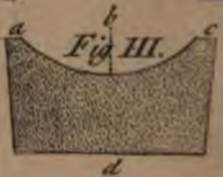


Fig. III.

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FIG. III. *A* Coppel *cut perpendicularly.*

a. b. c. *The Cavity that contains the Metal.*

d. *The Bottom of it* (§ 176.)

FIG. IV. *A* Box *made of Plate-braſs, and open at Top; being* ¾ *of an Inch in Diameter, and three Inches high.*

a. b. *Its Cover, having at Top a fine cloſe Hair-ſieve.*

c. *Through the Pores of which the Aſhes wherewith the Box is filled may be ſhaken out* (§ 178.)

FIG. V. *A wooden-*Peſtle *like that* FIG. I. *to make Teſts.*

a. b. c. *The convex Part which forms the Cavity of the Teſts.*

FIG. VI. *An hollow wooden-*Ring *cut perpendicularly, which is filled with a Maſs of Clay, and incompaſſed with* a. a. b. b. *an iron-Ring, leſt it ſhould break aſunder* (§ 187---191.) *while the Matter is beaten into it.*

FIG. VII. *A ſcorificatory* Teſt *cut perpendicularly. The Diameter of it muſt be about two Inches. Its Bottom* a. b. *muſt be narrower, that it may ſooner grow warm in the Fire* (§ 186.)

c. d. e. *Its Cavity.*

FIG. VIII. *A large* aſh-Veſſel, *or* Coppel, *incompaſſed with an iron-Ring* h. i. k. l.

a. b. c. *The Cavity of it, like a ſpherical Segment, ſurrounded with a Border* d. e. f. g.

h. i. k. l. *An iron-Ring, to retain the Aſhes* (§ 185.)

FIG. IX. *A* Shaver, *curved according to the ſaid ſpherical Segment, to cut the Aſhes preſſed cloſe, in order to make the Cavity of the aſh-Veſſel* (FIG. VIII.)

a. *Its Edge.*

b. *Its Back.*

c. d. *Two Handles to hold it* (§ 184. N° 3.)

FIG. X. *A Hand rowling about a ſmooth wooden-*Ball, *therewith to preſs cloſe to the Cavity the dry bone-Aſhes ſprinkled upon it, that it may be made very ſmooth* (§ 184. N° 3. & 4.)

FIG. XI. *A large* aſh-Veſſel, *framed in an earthen-Diſh* a. b. c. d.

e. f. g. *Its Border* (§ 184.)

h. *Its ſpherical Cavity.*

FIG. XII. *A toothed, wooden*-Peſtle, *to preſs cloſe the Aſhes put into the earthen Diſh* (§ 184. N° 2.)

FIG. XIII. *A ſmall, ſemi-cylindrical* Mould, *to form the docimaſtical Muffle.*

a. b. c. d. *Its convex Back.*

c. g. a. *Its hinder-Plane.*

b. d. e. f. *Its fore-Plane.*

h. *A Hole in the fore-Plane, wherein to faſten the Screw,* p. *with which the Mould may be pulled out, when the back and the hinder-Plane of it are covered with Clay cloſely applied to them* (§ 199. N°. 200.)

FIG. XIV. *A* concave Mould, *which being applied to the foregoing* (FIG. XIII.) *the Muffles are made ſooner, and more ſolid.*

l. *A ſemi-cylindrical Cavity, which is larger than the foregoing convex Mould* (FIG. XIII.) *to make the Thickneſs of the Muffle. The hollow Surface of it is done over with the clayey Matter.*

m. *The hinder-Board, where the Muffle muſt be cloſe.*

r. *The fore-Board, which ſerves for preſſing the Matter cloſe.*

i. i. k. k. *Two Screws, the ſcrew-holes of which are in the hinder-Board, to make the hinder and the fore-Board draw towards each other.*

o. n. *The upper-Board which makes the Bottom or Floor of the Muffle. It is furniſhed with another ſmall tranſverſal Board,* q. *that it may reſiſt the Effort of the Screws* g. g. (§ 200.)

s. *The Nuts of the Screws* g. g.

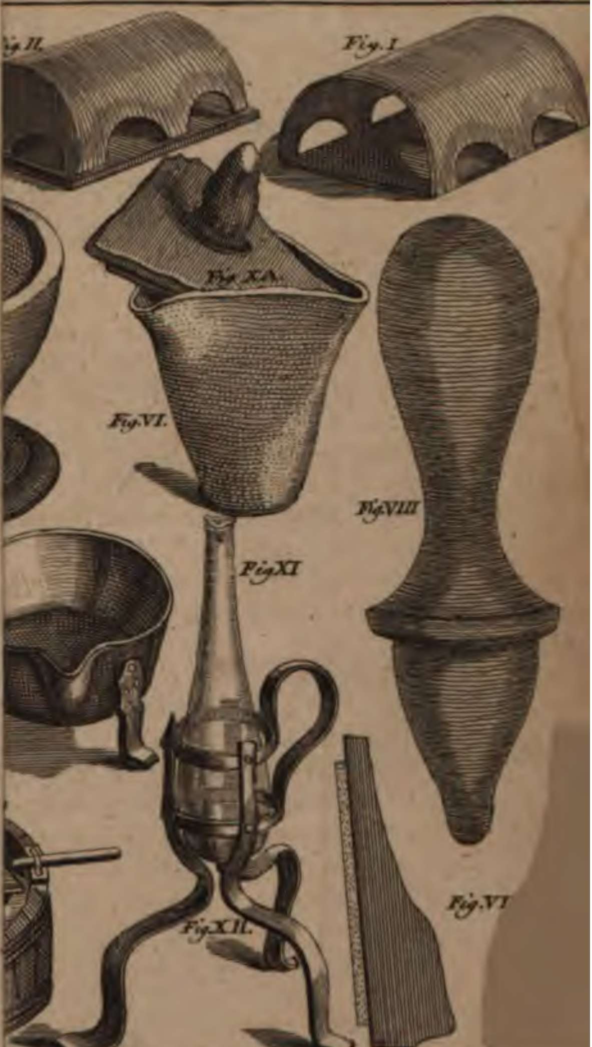
PLATE II.

FIG. I. *A docimaſtical* Muffle, *with a fixt Bottom. It is ſeen on the fore-part, and ſide-ways* (§ 194.)

FIG. II. *A docimaſtical* Muffle *ſet upon a moveable Bottom, and to be ſeen on the hinder-part, and laterally.*

FIG.

Pl. II.



ig. II.
Fig. I
Fig. X A.
Fig.VI.
Fig.VIII
Fig.XI
Fig.XII.
Fig.VI

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FIG. XVI. *The wooden or earthen* waſhing-Trough *or Tray, to waſh off the lighter and unprofitable Particles adhering to the Ores. It reſembles a ſmall Boat, is about one Foot long, and a few Inches broad and deep. The hinder and higher Part of it ſerves as a Handle to it* (§ 214.)

FIG. XVII. *The granulatory wooden* Box (§ 215.)

FIG. XVIII. *The* granulatory *cylindrical* Machine, *put upon a Veſſel full of Water, ſo that its under-ſide may be immerſed in the Water. The Metal to be granulated is poured upon* [illegible] *urns* (§ 217.)

FIG. XIX. *The* mel[illegible], *which is of Copper or Iron* (§ 220.)

FIG. XX. *A* Set of Mo[illegible] *make Ingots* (§ 223.) *of Metals.*

FIG. XXI. *A* Mould *with* [illegible]*berical Segments, for the metallick* Regulus's *which* [illegible] *to be put into the Coppel* (§ 224.)

PLATE III.

FIG. I. *The* Docimaſtical *or* Eſſay-Furnace.

a a. b b. c c. *The* Body *of the Docimaſtical Furnace* (§ 232.)

d. *Its Aperture at Top.* (Ibid. N° 1.)

e. *The Door of the Aſh-hole.*

k. k. *Sliders to ſhut the Door.*

f. *The upper-Door that is contiguous to the Muffle, which is ſeen within, in its proper Situation, together with two Coppels in it.*

l. l. *Sliders to ſhut the upper-Door.*

m. *An oblong Hole in one of the Sliders.*

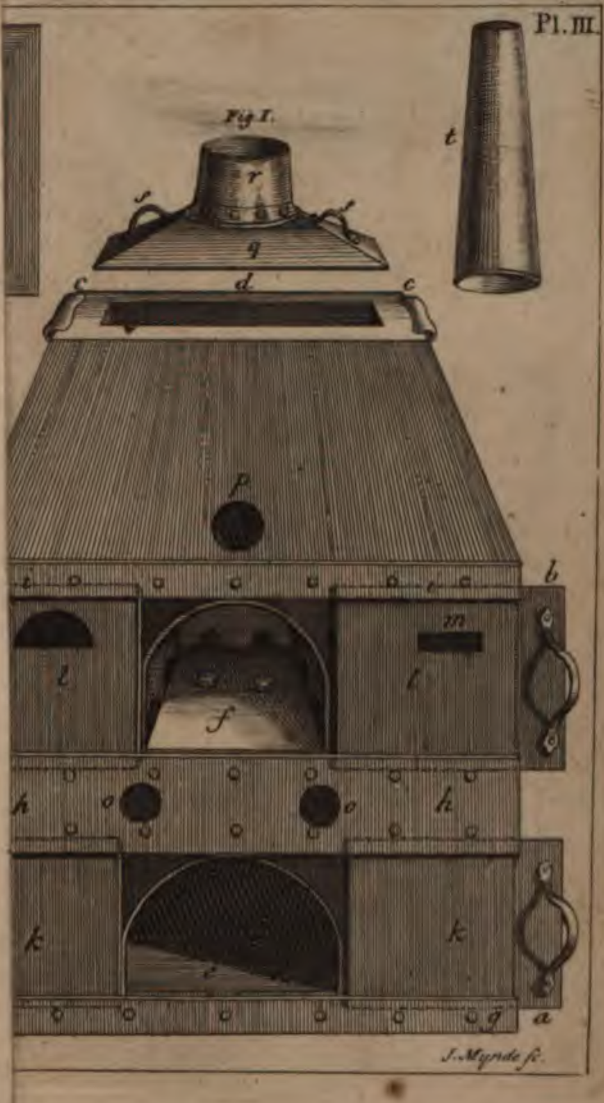
n. *Another ſemi-circular Hole in the other Slider, through which one may look into the Muffle when the Door is ſhut.*

g. g. h. h. i. i. *Iron-Plates, rivetted to the Furnace, and making between them and the Sides of the Furnace, Grooves in which the Sliders of the Doors may move.*

o. o. *Two Holes, to which two others like them made in the hinder-part of the Furnace, do correſpond, and through*

Pl. III.

Fig. I.



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through which two ſmall iron-Bars are introduced to ſuſtain the Muffle.

p. *A round Hole open in the upper-Part of the Furnace, that the Aſhes and burning Coals may be ſtirred with a ſmall iron-Rod introduced through it.*

q. *The Cover, which may be moved backward and foreward, between the iron-Plates* c. c, *rivetted to the Right and Left upper-Edge of the Furnace, and turned down.*

r. *A Segment of a Cylinder faſtened at Top of the Cover* q.

s. s. *The Ears of the Cover, ſerving as a Funnel, or Flue, and upon which an iron-Pipe may be put.*

t. *The conick Tube to be put upon the Segment* r. *of the Cover, ſerving as a Funnel or Flue to excite the Fire.*

FIG. II. *A ſquare* Ledge *divided into two Parts, and to be placed within, at Top of the upper-Border of the Door of the Aſh-hole* (FIG. I.) e. *and upon which the Lute wherewith the Furnace is inwardly done over, and the priſmatical iron-Bars which ſuſtain the Grate, do reſt.*

FIG. III. *Is the perpendicular Section of the Furnace* (FIG. I.) *paſſing through the Middle of the fore and hinder-Surface, that one may openly ſee the inward Diſpoſition of the Furnace, as if one ſhould look into it ſideways.*

FIG. IV. *The Furnace cut perpendicularly, the Section paſſing through the Sides of it; to ſhew the inward Diſpoſition, as if one ſhould look into it backwards and forwards.*

FIG. V. *An elliptical* wooden Mould, *according to which the inward Cavity of the Furnace repreſented in the* following FIG. *muſt be formed.*

a. *The upper Part cut off, which forms* (FIG. VII.) *the inferior Extremity, muſt be cut off in the ſame Manner, to make the Body of the Furnace.*

FIG. VI. *The* melting Furnace, *made according to the Mould* (FIG. V.)

d. *An iron Ring, applied to the Border of the Furnace, to hold in the Lute wherewith the Inſide of the*

Furnace is done over. A like one is faſtened at the lower Part of the Furnace.

e. e. *Ears, to lift up and manage the Furnace.*

c. c. *Two Holes, facing which there are two other like ones behind, through which are paſſed the two ſmall iron-Bars* (FIG. XI.) *wherewith the Grate* (FIG. XII.) *is ſupported.*

FIG. VII. *The* Cover, *to ſet upon the Furnace, when a ſtrong Fire and Draft of Air is neceſſary. The Figure of it may be the Complement of the Part cut off of the Ellipſis* (FIG. V.) a.

b. *Is a Door hung on Hinges, through which the Fuel of the Fire is introduced into the Furnace.*

c. c. *The Ears of the Cover.*

d. *A Segment of a Cylinder, upon which an iron-Tube may be put in the Manner of a Funnel to increaſe the Fire; like that put upon the docimaſtical Furnace* FIG. I. t.

FIG. VIII. *The Door of the Cover of* FIG. VII. *ſeen on the Inſide, with a projecting iron Plate all round it, to faſten the Lute wherewith it is coated.*

FIG. IX. *The aſh-Hole, or bottom-Part, on which the Furnace* (FIG. VI.) *is put.*

c. *An iron-Ring on which the Furnace is ſupported.*

d. *A Hole to introduce the Noſel of the Bellows.*

b. *A Door, to admit the Air, and take out the Aſhes.*

FIG. X. *Another bottom-Part, coated within, and forming the Bed* f. g. h. *which receives the melted Metal.*

c. *A Hole to introduce the Poker.*

d. *A Hole for the Noſel of the Bellows.*

e. *A Hole from which the melted Matter may be let out of the Bed within, through a Channel that reaches from the Bottom of the ſaid Bed* g. *down to the ſaid Hole.*

FIG. XI. *Two ſmall iron-Bars, which are introduced through the Holes* o. o. *of the docimaſtical Furnace* FIG. I. *or through the Holes* c. c. *of the melting Furnace* (FIG. VI.) *in the former to ſupport the docimaſtical Muffle, and to ſupport the Grate in the latter.*

FIG. XII. *The Grate for the melting Furnace.*

FIG. XIII. *The ſame bottom-Part of* FIG. X. *but ſo diſpoſed, as that the melted Matter collected in the Bed of it, may be let out through the Hole* e. FIG. X. *and be received into a Baſon* i. *placed on the Outſide, ſurrounded with burning Coals.*

PLATE IV.

FIG. I. *The* Athanor (§ 242.)

a. a. a. a. *The Tower of the* Athanor, *or chief Furnace, which receives the Fuel of the Fire: The pricked Lines indicate the Thickneſs of the Wall.*

b. b. b. b. *The inner Sides which form the Cavity, and are each ten Inches long.*

c. *The Door of the aſh-Hole.*

e. *The upper-Door.*

d. *The Grate, which is placed even with the Bottom of the Door* e.

f. *The Cover wherewith the upper-Aperture of the Tower is ſhut.*

g. g. *A Flue, through which the Fire aſcends from the Tower into the firſt Furnace.*

h. h. h. h. *A hollow Priſme, which forms the firſt ſecondary Furnace.*

i. i. *A ſemi-cylindrical Arch, wherewith the aforeſaid Priſme is cloſed at Top.*

k. k. k. k. *An iron-Plate coated within, wherewith the fore-Part of the firſt ſecondary Furnace is ſhut.*

l. *A round Hole in the Plate* k. k. k. k, *through which the Neck of the Veſſel* 7. *may be paſſed.*

m. *A Stopple, wherewith the Hole* l. *may be ſhut.*

n. n. *Iron-bars.*

o. o. o. o. *Iron-hooks faſtened in the Wall, to receive the Iron-bars.*

6. *An iron-Door to ſhut the Flue* g. g.

p. p. p. p. *Iron-chains, with which the ſaid Door may be lifted up.*

*. *. *Hooks on which the Door may be ſuſpended with the Chains at any determined Height.*

q. q. q.

q. q. q. q. *The Funnel of this Furnace.*

r. r. *An iron-Plate, wherewith the Funnel may be ſhut and opened.*

s. s. s. s. *A ſquare Iron-Frame made of a double Plate, receiving the Plate* r. r.

t. t. *Another Flue, through which the Fire paſſes from the firſt ſecundary Furnace into the ſecond.*

u. u. u. u. *Another ſecundary Furnace cylindrical.*

v. v. *Its upper circular Aperture, ſloped at the fore-Part, to receive.*

w. w. *An iron-Pot which is to be hung in this ſecond ſecundary Furnace.*

x. x. *An iron-Ring, by which the Pot* w. w. *reſts upon the upper-Border of the Furnace.*

y. *A Segment cut out of the Pot, and correſponding with the foregoing* v. v.

z. *A Flue, which conveys the Fire from the ſecond into the third Furnace.*

1. 1. 1. 1. *The Third ſecundary Furnace, like the ſecond, and having alſo a Pot.*

2. 2. 2. 2. *The ſecond Funnel.*

3. *A Plate, to ſhut open the Funnel.*

4. *An Aperture which leads from the third Furnace into the Funnel.*

5. 5. 5. *The third Funnel.*

7. *An earthen Retort, placed in the firſt ſecundary Furnace* k. k. i. i. *having its Neck through the Hole of the Door thereof.*

8. *A Recipient.*

9. *A glaſs-Retort, placed in the iron-Pot of the ſecond ſecundary Furnace, which Pot is filled with Sand.*

10. *A Recipient.*

11. *A Cucurbite placed in the Pot of the third Furnace.*

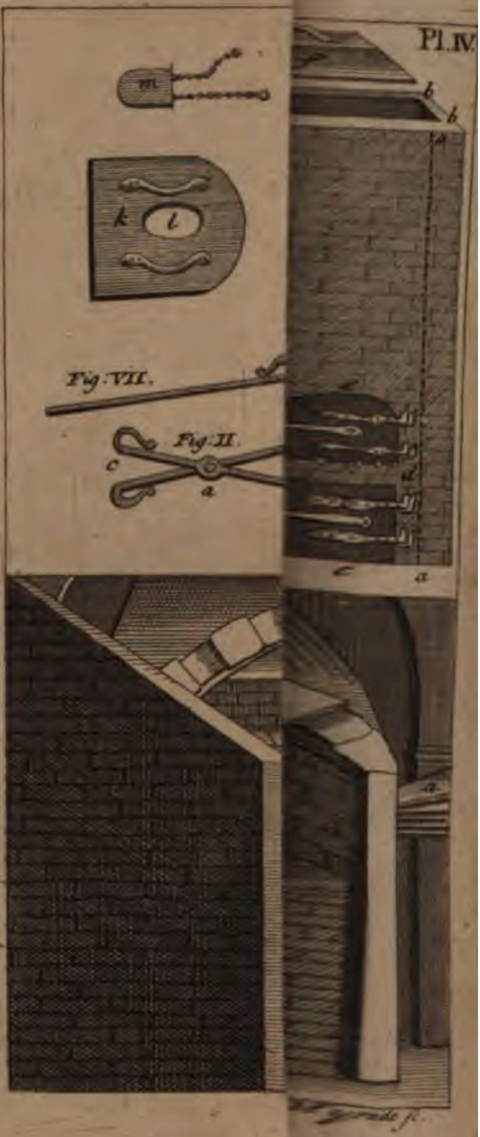
12. *Stands, which ſupport the Recipients, and which may be raiſed, or lowered with Screws.*

FIG. II. *A Pair of* Tongs, *to take the Teſts and Coppels out of the Fire.*

a. *An iron-Rivett, wherewith the two Legs of the Tongs are joined.*

b. *The*

Pl. IV.



emi-lunar anterior Part of the Tongs,
e Veſſels are taken hold of.
ars wherewith the Tongs are laid hold of
.
A Pair of Pincers, *to take up ſmall*
ſmall Weights.
A Pair of Tongs, to take Crucibles and
eſſels of a middling Size, out of the Fire.
A Pair of Tongs, *to embrace large Cru-*
he largeſt Veſſels charged with a great
Metal.
e ſemi-Circle faſtened at one of the Legs of

ble ſemi-Circle faſtened at the other Leg,
epts the foregoing ſemi-Circle a, *when you*
gs.
*A ſmall iron-*Hook, *to ſtir the Matter*
out under the docimaſtical Muffle.
. *A Rod of Iron, two Foot and an half long,*
Inch thick, to ſtir the burning Coals and the
e Convexity of the docimaſtical Muffle, put
ce PLAT. III. FIG. I.
I. *An iron-*Hook, *three Foot long, and from*
half an Inch thick, to ſtir the Maſſes in the
in the wind-Furnace.
The Poker, *wherewith the melted Metal*
e in the large Teſt are ſtirred.
A Poker, *to be introduced through the Door*
ole, to free the Grate of the Aſhes or ſmall
with it is obſtructed.
. *A ſmall iron-*Ladle, *with a long Handle,*
he Matter is put into the Veſſels that are in

. *A wooden-*Screen, *with a Slit in it,* a.
II. *A cementatory or* blow-Pipe.
V. *A* Smith's Forge *not deſcribed indeed*
regoing Furnaces, but eaſy to be known from
as much as is required in Practice.
le Pair of Bellows,

b. *A*

b. *The ſemi-lunar anterior Part of the Tongs, wherewith the Veſſels are taken hold of.*

c. *The Ears wherewith the Tongs are laid hold of and managed.*

FIG. III. *A Pair of* Pincers, *to take up ſmall Grains, and ſmall Weights.*

FIG. IV. *A Pair of Tongs, to take Crucibles and other open Veſſels of a middling Size, out of the Fire.*

FIG. V. *A Pair of* Tongs, *to embrace large Crucibles, and the largeſt Veſſels charged with a great Quantity of Metal.*

a. *A ſingle ſemi-Circle faſtened at one of the Legs of the Tongs.*

b. *A double ſemi-Circle faſtened at the other Leg, which intercepts the foregoing ſemi-Circle* a, *when you ſhut the Tongs.*

FIG. VI. *A ſmall iron-*Hook, *to ſtir the Matter in the Teſts put under the docimaſtical Muffle.*

FIG. VII. *A Rod of Iron, two Foot and an half long, and half an Inch thick, to ſtir the burning Coals and the Aſhes upon the Convexity of the docimaſtical Muffle, put in the Furnace* PLAT. III. FIG. I.

FIG. VIII. *An iron-*Hook, *three Foot long, and from a quarter to half an Inch thick, to ſtir the Maſſes in the Crucibles put in the wind-Furnace.*

FIG. IX. *The* Poker, *wherewith the melted Metal or the* Scoriæ *in the large Teſt are ſtirred.*

FIG. X. *A* Poker, *to be introduced through the Door of the aſh-Hole, to free the Grate of the Aſhes or ſmall Coals wherewith it is obſtructed.*

FIG. XI. *A ſmall iron-*Ladle, *with a long Handle, wherewith the Matter is put into the Veſſels that are in the Fire.*

FIG. XII. *A wooden-*Screen, *with a Slit in it,* a.

FIG. XIII. *A cementatory or* blow-Pipe.

FIG. XIV. *A* Smith's Forge *not deſcribed indeed among the foregoing Furnaces, but eaſy to be known from this Figure, as much as is required in Practice.*

a. *A double Pair of Bellows,*

b. *A Hole made in the ſide Wall, through which the Nozel of the Bellows communicates with the Forge.*

c. *A ſmall Pit, in which the Veſſels or the larger Teſt may be put.*

FIG. XV. A. *a* Furnace, *for a large Teſt covered with a Muffle, the fore-Part of which is open, that the inward Diſpoſition of it may be ſeen.*

a. *The Teſt.*

b. *The Muffle.*

c. c. *Two air-Holes, through which the Air may enter to excite the Fire.*

e. e. e. e. *Apertures which admits the Air.*

B. *A like Furnace, ſhut before.*

d. *A Door to which the Muffle is contiguous, that the Metal and* Scoria's *may be ſeen within, and ſtirred.*

PLAT. V.

FIG. I. *A Pair of* double Bellows, *with their Frame.*

a. a. a. a. Iron-ſtays, *faſtened to the Uprights of the Frame of the Bellows, every one of which may receive the Trunions or Axles of the Bellows, that they may be raiſed or lowered at pleaſure.*

b. b. *Iron-*Keys, *wherewith the Trunions are faſtened, leſt they ſhould ſlip off when the Bellows are worked.*

c. c. *Two Uprights, which receive the Nozel of the Bellows.*

d. d. d. d. Holes *in the Uprights* c. c.

e. *An iron-*Pin, *which being paſſed through the Holes* d. d. d. d. *ſuſtains the Nozel of the Bellows, that it may be raiſed or lowered.*

f. *A* Weight, *which diſtends the lower Part of the inferior Bellows.*

g. *A* Weight, *wherewith the upper Part of the Bellows are charged, that they may be preſſed down by a determined Force.*

h. *The* Handle, *wherewith the Bellows are worked.*

i. *A* Chain, *on which the Bellows are ſuſpended, when at reſt.*

FIG. II. *The* docimaſtical Balance.

a. b. *The* Beam.

c. *The* Tong.

FIG. III. *The* Fork.

a a. *Two Holes, in which the Axis turns.*

d. d. *Two* Holes, *which retain the Claſp.*

c. *The* Needle, *which ſhews the Equilibrium.*

b. *An* Aperture, *that the Tongue* (FIG. II. c.) *may be ſeen in the Place where it correſponds to the Point of the Needle.*

FIG. IV. *The* Claſp.

FIG. V. A. A. *The* Diſhes, *or* Scales, *which are ſuſpended with Silk-ſtrings, on the Extremities of the Beam* (FIG. II.) a. b.

B. B. *Two moveable* Diſhes, *which, being loaded with the Weights and Things to be weighed, are put into the foregoing Diſhes.*

FIG. VI. *The* Support, *on which the Balance is ſuſpended.*

a. *The* Pedeſtal.

b. *The Pillar.*

c. *An* Arm.

d. *The firſt* Pully.

e. *The ſecond* Pully.

f. *The third* Pully.

g. *Another* Arm.

h. *An oblong* Hole.

i. *A ſmall* Plate, *to be introduced through the Hole* h.

k. *A* Weight *faſtened on a Silk-ſtring, wherewith the Balance may be kept raiſed.*

FIG. VII. *A* Caſe, *in which the Balance it put up.*

a. a a. *The Windows.*

b. *The* Support (FIG. VI.) *with the Balance.*

c. *The Silk*-ſtring *conveyed through a ſmall Hole made at bottom of the fore-Window, wherewith the Balance may be raiſed or lowered, when the Caſe is ſhut.*

awers, *wherein the Weights, Scales, and other* *nſils are put up.*

. VIII. *It ſhews the* Weights *incloſed in a Box.*

. IX. *The* Proof-Needles, *faſtened together.*

a. a. a. *The Extremities of them which are rubbed againſt the Touch-ſtone.*

FIG. X. *The* Touch-ſtone.

P L A T. VI.

FIG. I. *The glaſs*-Furnace *to be ſeen on the fore-part.*

A. *The inferior* Chamber, *which is the aſh-hole.*

a. *Its Door through which the Aſhes are taken out, and the Wind is admitted either immediately or by Means of the Pipe* b. *which is conveyed thither from a Hole made in the Wall of the Laboratory.*

c. *The Place where the iron-Bars are put.*

d. d. *The Ledge upon which the Iron-bars reſt, and whereon the Veſſels are put.*

B. *The ſecond* Chamber, *or fire-Place.*

e. *The great Door.*

f. f. *The ſmaller Doors.*

C. *The third Chamber.*

g. *A Hole, through which the Flame paſſes from the ſecond into the third Chamber.*

h. h. h. *Doors.*

i. i. *The Hearth or Floor.*

D. *The fourth* Chamber.

k. k. *A quadrangular Hole for the Paſſage of the Fire.*

l. *The Door.*

m. *The Funnel.*

n. n. n. n. &c. *prickt Lines, ſhewing the Form of the inward Cavity of the Furnace.*

o. o. o. o. o. o. o. *Small Holes made through every Door.*

FIG. II. *The* Furnace *repreſented at the hinder-part.*

FIG. III. *The Picture of the Furnace cut perpendicularly in the Middle: Together with a Repreſentation*

Fig

a
Fig IV.

of the Veſſels within. The Letters correſpond with thoſe of FIG. I.

FIG. IV. *A cylindrical* Veſſel *ſhut cloſe at Top.*

a. *A Hole through which the Matter may be put into it, and examined when therein.*

FIG. V. *A common triangular* Crucible, *adapted to the ſame Uſe as the foregoing* FIG. IV.

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